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Quality of Life of Children with Chronic Kidney Disease Undergoing Hemodialysis and Peritoneal Dialysis: A Systematic Review and Meta-Analysis

Muhammad Febian Zufar, Risky Vitria Prasetyo*, Widodo, Dwiyanti Puspitasari
Universitas Airlangga, Indonesia
Email : muhammad.febian.zufar-2022@fk.unair.ac.id, risky-v-p@fk.unair.ac.id* , wid22@yahoo.com, dwiyanti-p@fk.unair.ac.id

Keywords:
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Peritoneal Dialysis;
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ABSTRACT

Chronic kidney disease (CKD) can substantially affect children's daily activities, emotional well-being, social relationships, and educational participation. Hemodialysis (HD) and peritoneal dialysis (PD) impose different treatment-related demands, and their associations with health-related quality of life (HRQoL) remain uncertain. This systematic review and meta-analysis aimed to compare physical, emotional, social, and school functioning among children receiving these two dialysis modalities. Following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, a systematic literature search was conducted using PubMed, Google Scholar, Scopus, and SpringerLink to identify cross-sectional studies employing the Pediatric Quality of Life Inventory (PedsQL) 4.0 Generic Core Scales. Risk of bias was assessed using the Risk of Bias in Non-randomized Studies of Exposures (ROBINS-E) tool, and pooled mean differences were calculated separately for child self-reports and parent-proxy reports. Five studies contributed data from 142 children and 154 parent-proxy respondents. No statistically significant differences between dialysis modalities were identified across the physical, emotional, social, or school functioning domains from either reporting perspective. Pooled estimates favored PD for physical and emotional functioning and HD for social functioning, although these differences were not statistically significant. Estimates for school functioning were close to zero, with differences in direction between child self-reports and parent-proxy reports. Substantial heterogeneity in several domains and the limited number of eligible studies restricted the certainty of the findings. Overall, the available evidence did not establish a significant HRQoL advantage for either dialysis modality. Clinical decisions should consider medical indications, children's educational needs, and family circumstances. Larger prospective multicenter studies with appropriate adjustment for potential confounding factors are needed to clarify the relationships between dialysis modality and HRQoL outcomes in children with CKD.

INTRODUCTION

Chronic kidney disease (CKD) in children is a significant health concern that affects not only physical health but also overall quality of life (QoL) (Fibrianto et al., 2023; Guha et al., 2023). Pediatric CKD is characterized by persistent abnormalities in kidney structure or function and may progress over time, leading to complications such as growth impairment, chronic kidney disease–mineral and bone disorder (CKD-MBD), hypertension, and

cardiovascular disease. Previous studies have demonstrated that CKD progression varies considerably among children, depending on factors such as baseline kidney function and proteinuria, which are associated with changes in estimated glomerular filtration rate (eGFR) (Yang et al., 2024). The progressive nature of CKD often necessitates ongoing medical management, including dietary modifications, regular hospital visits, and kidney replacement therapy, such as dialysis or kidney transplantation. These interventions may disrupt children's daily routines, emotional well-being, educational participation, and social interactions (Kidney Disease: Improving Global Outcomes [KDIGO], 2024).

Quality of life is an important outcome measure for evaluating the overall well-being of pediatric and adult patients, encompassing physical, emotional, social, and functional dimensions. In children, QoL assessment is particularly important because it reflects developmental and psychosocial challenges associated with chronic or life-threatening conditions (Toro-Pérez et al., 2023). Evaluating QoL can help guide clinical decision-making, assess treatment outcomes, and inform comprehensive, patient-centered care strategies. Furthermore, QoL assessments can reveal the broader effects of chronic illness on family functioning and caregiving responsibilities, highlighting the interconnected experiences of children and their caregivers (Eiser & Jenney, 2007).

In Indonesia, the pooled prevalence of CKD among children has been estimated at 0.75%, based on a systematic review of 22 studies involving more than 8,500 children. Reported prevalence estimates were higher in urban areas, ranging from 0.85% to 1.25%, than in rural areas, where estimates ranged from 0.30% to 0.85%. The most commonly reported causes of pediatric CKD in Indonesia include congenital anomalies of the kidney and urinary tract (CAKUT), hereditary nephropathies, and glomerulonephritis, while infectious causes account for a smaller proportion of cases (Leona, 2024).

Understanding QoL among children with CKD is essential because the disease and its treatment can substantially affect physical functioning, emotional well-being, social participation, and educational development. Children with CKD often require dietary restrictions, frequent medical evaluations, and complex treatment regimens that may interfere with daily activities and age-appropriate developmental experiences. Previous research has demonstrated that children with CKD have lower QoL scores across multiple domains than their healthy peers, particularly in physical functioning and school performance (Ruidiaz-Gómez & Higuita-Gutiérrez, 2020). Another study found that parent-reported QoL scores were higher among younger children with CKD than among older children, whereas greater medication burden was associated with lower QoL scores. Early identification of QoL impairments may help healthcare professionals implement interventions that address both disease management and psychosocial well-being, including reducing treatment burden and providing appropriate emotional support (Díaz-González de Ferris et al., 2021).

According to Kidney Disease: Improving Global Outcomes (KDIGO, 2024), CKD is defined as abnormalities of kidney structure or function that persist for at least three months and have implications for health. Diagnostic criteria include markers of kidney damage or a glomerular filtration rate (GFR) below 60 mL/min/1.73 m² for at least three months. CKD is classified according to cause, GFR category (G1–G5), and albuminuria category (A1–A3), collectively referred to as the CGA classification. However, age-specific considerations are necessary in children younger than two years because normal GFR values increase during early

childhood (Kementerian Kesehatan Republik Indonesia [Kemenkes], 2023). CAKUT represents a major cause of pediatric CKD (Kemenkes, 2023). Other etiologies include steroid-resistant nephrotic syndrome, chronic glomerulonephritis, lupus nephritis, Alport syndrome, and renal ciliopathies. Less common causes include thrombotic microangiopathy, nephrolithiasis, nephrocalcinosis, kidney tumors, and infectious or tubulointerstitial kidney diseases (Becherucci et al., 2016).

Children with CKD are vulnerable to multiple complications that may adversely affect growth, development, and overall well-being. Growth impairment may occur during the early stages of CKD but is generally more pronounced in younger children with moderate to severe disease. Contributing factors include inadequate nutritional intake, metabolic acidosis, and disturbances in the growth hormone–insulin-like growth factor 1 (IGF-1) axis. Anemia is another common complication, primarily associated with reduced erythropoietin production and iron deficiency. Untreated anemia may contribute to fatigue, dizziness, impaired concentration, increased hospitalization risk, left ventricular hypertrophy, and greater overall morbidity (Becherucci et al., 2016; VanSickle & Warady, 2022). Children with CKD are also at risk of CKD-MBD due to abnormalities in calcium, phosphate, and related hormonal regulation. Cardiovascular complications include left ventricular hypertrophy, increased arterial stiffness, and increased carotid intima-media thickness, with hypertension representing a major modifiable cardiovascular risk factor (VanSickle & Warady, 2022). Additionally, metabolic acidosis may develop as kidney function declines because of impaired acid excretion and reduced bicarbonate regeneration, potentially affecting children's nutritional status, growth, and development (Adamczak & Surma, 2021).

The management of pediatric CKD requires a multidisciplinary approach that includes strategies to slow disease progression, optimize nutrition, manage complications, provide kidney replacement therapy when indicated, and address psychosocial needs (VanSickle & Warady, 2022). Peritoneal dialysis (PD) is widely used in pediatric patients, particularly younger children, because it can be performed at home and offers greater flexibility in daily scheduling. Home-based treatment may facilitate school attendance and reduce the need for frequent visits to dialysis centers. PD may also offer advantages in preserving residual kidney function, although outcomes vary according to patient characteristics and treatment circumstances. However, PD requires substantial caregiver involvement and adherence to infection prevention procedures. The principal PD modalities include continuous ambulatory peritoneal dialysis (CAPD) and automated peritoneal dialysis (APD). APD is frequently preferred in pediatric practice because overnight exchanges may reduce interference with daytime activities, although modality selection depends on clinical indications, family circumstances, and available resources (Kemenkes, 2023). Hemodialysis (HD), in contrast, removes metabolic waste products and excess fluid from the bloodstream through an extracorporeal circuit and dialyzer. Conventional in-center HD is commonly performed approximately three times per week, although treatment frequency and duration vary according to individual clinical requirements. HD requires reliable vascular access and may interfere with school attendance and social activities because of travel requirements and scheduled treatment sessions. Kidney transplantation is generally the preferred kidney replacement therapy for eligible children with kidney failure because it is associated with better survival, growth, and QoL outcomes than long-term dialysis (VanSickle & Warady, 2022).

Both dialysis modalities are associated with complications that may influence treatment burden and QoL. During HD, patients may experience intradialytic hypertension, hypotension, headaches, muscle cramps, nausea, and vomiting. A study involving 25 pediatric patients and 519 HD sessions reported hypertension in 40.46% of sessions, hypotension in 3.4%, headaches in 13.87%, muscle cramps in 8.6%, and vomiting in 1.73%. Vascular access-related complications included catheter infections, thrombosis, and accidental catheter dislodgement, with reported frequencies of 12.5%, 0.77%, and 0.57%, respectively (Cho, 2020; Hafeez, 2005). Other complications reported among children receiving HD included cardiovascular abnormalities (72%), anemia (83%), dermatologic problems (78%), and neurological symptoms (86%) (Naheed et al., 2023). Hemodynamic instability and dialysis disequilibrium syndrome remain additional clinical concerns, particularly among younger patients and those initiating dialysis (Shin et al., 2015). In children receiving PD, peritonitis is a major infectious complication and an important cause of hospitalization and technique failure (Chadha et al., 2009). Previous research reported that more than half of children undergoing CAPD experienced at least one episode of peritonitis, with an incidence of approximately one episode per 19.57 patient-months (Wisanuyotin et al., 2020). Exit-site and catheter tunnel infections are additional concerns, particularly among infants and younger children (Marie et al., 2022), and severe or recurrent infections may necessitate catheter removal or replacement (Chadha et al., 2009). Noninfectious complications include catheter obstruction, catheter malposition, dialysate leakage, abdominal hernias, and ultrafiltration failure (Prakash et al., 2011).

The World Health Organization (WHO, 2012) conceptualized QoL as individuals' subjective perceptions of their lives in relation to their cultural contexts, values, expectations, goals, and concerns. Among children, QoL is influenced by interactions among socioeconomic conditions, family functioning, physical and mental health, educational opportunities, and community environments. Children from socioeconomically disadvantaged households, including those experiencing parental unemployment or limited educational resources, may be at increased risk of impaired QoL (You et al., 2022). Financial instability may also restrict access to healthcare services, educational opportunities, and social participation (Bonyan, 2023). Supportive and stable family environments can promote resilience, whereas family conflict, neglect, parental illness, and substance-related problems may contribute to developmental, emotional, and behavioral difficulties (Kallander et al., 2020). Positive family functioning has been associated with higher QoL, particularly among children living with chronic health conditions (Lestari et al., 2024). Chronic illnesses, disabilities, and psychological difficulties may further impair physical and psychosocial well-being (Mansker et al., 2023), while safe neighborhoods, recreational opportunities, and inclusive community resources can support healthy development and social participation (Duzel et al., 2023).

CKD can substantially affect children's physical functioning, emotional well-being, educational experiences, and family relationships. Physical manifestations, including growth impairment, fatigue, and reduced exercise tolerance, may limit participation in daily activities. Emotional challenges may include anxiety, depressive symptoms, and social isolation, while repeated hospital visits and dialysis schedules may disrupt school attendance and academic performance. Families may also experience psychological stress, caregiving demands, and financial difficulties associated with long-term treatment (Fibrianto et al., 2023). Health-related quality of life (HRQoL) among children with CKD is frequently assessed using the Pediatric

Quality of Life Inventory™ (PedsQL™), which includes child self-report and parent-proxy report versions. The PedsQL™ 4.0 Generic Core Scales assess physical, emotional, social, and school functioning, providing a multidimensional evaluation of children's perceived health and daily functioning. Previous studies have reported lower HRQoL scores among children with CKD, particularly in physical and emotional functioning (Fibrianto et al., 2023).

Although numerous studies have assessed QoL among children with CKD using instruments such as the PedsQL™, the comparative associations of HD and PD with specific HRQoL domains remain insufficiently established. Differences in treatment schedules, caregiver involvement, clinical characteristics, and educational participation may contribute to variations in children's experiences across dialysis modalities. Furthermore, findings from individual studies may be limited by small sample sizes and differences in study populations, making quantitative synthesis valuable for evaluating the available evidence. Therefore, this study conducted a systematic review and meta-analysis to compare HRQoL among children with CKD undergoing HD and PD. Specifically, the study examined differences in physical, emotional, social, and school functioning using PedsQL™ scores. It was hypothesized that children receiving PD would demonstrate higher HRQoL scores across these four domains than those receiving HD.

METHOD

This was a quantitative study with a meta-analysis design based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, which analyzes existing literature systematically by following the correct stages or research protocol. The PICOS used in this study is presented in Table 1.

Table 1. PICOS of the research design

Component	Description
P (Population)	Pediatric patients with chronic kidney disease
I (Intervention)	Hemodialysis
C (Comparison)	Peritoneal dialysis
O (Outcome)	Quality of life
S (Study design)	Cross-sectional

The review included cross-sectional studies involving children with chronic kidney disease (CKD) undergoing hemodialysis or peritoneal dialysis that assessed health-related quality of life using the Pediatric Quality of Life Inventory (PedsQL) 4.0 Generic Core Scales. Studies were excluded if the full text was unavailable, PedsQL 4.0 data were incomplete, or the articles were published in languages other than English or Indonesian. A systematic literature search was conducted using PubMed, Google Scholar, Scopus, and SpringerLink, with relevant English and Indonesian keywords related to pediatric CKD, dialysis modalities, and health-related quality of life, combined using the Boolean operators AND and OR. Dialysis modality was the independent variable, while health-related quality of life was the dependent variable, as detailed in Table 2. The systematic review was conducted from April 2025 to July 2026.

Table 2. Operational definitions

Variable	Operational definition	Measurement method	Measurement scale
Quality of life	A person's perception of their well-being and satisfaction in daily life	Questionnaire	Ordinal
Dialysis modality	The method of blood purification in CKD patients	Any measurement method	Nominal

Data collection involved a systematic literature search, removal of duplicate records, screening of titles and abstracts, full-text eligibility assessment, and critical appraisal of the included studies. Studies were selected according to predefined inclusion and exclusion criteria, and the reasons for exclusion were documented in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram. The methodological quality of the included studies was assessed using the Risk of Bias in Non-randomized Studies of Exposures (ROBINS-E) tool. Relevant data were extracted, including the first author's name, publication year, study title, population characteristics, study design, age range, dialysis modality, disease severity, and health-related quality-of-life scores. The extracted data were subsequently organized and summarized in tables.

Data were analyzed using narrative synthesis and quantitative meta-analysis. The narrative synthesis summarized study characteristics and findings according to the Population, Intervention, Comparison, Outcomes, and Study Design (PICOS) framework, with particular attention to differences in quality of life between children undergoing hemodialysis and peritoneal dialysis. Quantitative analyses were performed using Review Manager (RevMan) software, and pooled effect estimates were presented in forest plots. Separate analyses were conducted for the physical, emotional, social, and school functioning domains, based on the available quality-of-life scores. The study's methodological framework is presented in Figure 1

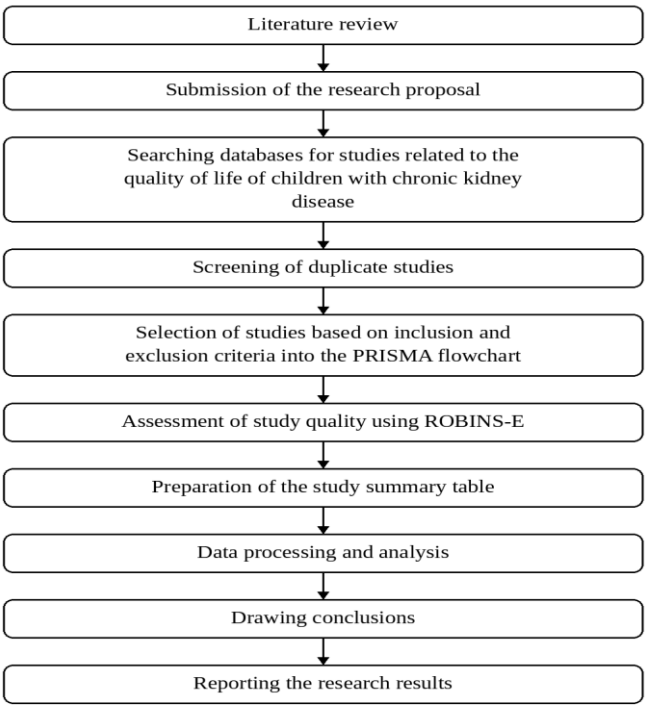

Figure 1. Operational framework of the study

RESULTS AND DISCUSSION

Study Selection

A comprehensive search of the PubMed, Google Scholar, SCOPUS, and Springer databases yielded a total of 475 articles. A total of 32 articles were excluded as duplicates. The abstracts of 339 articles were screened, resulting in 48 articles being included. Subsequently, in the full-text screening, 47 full texts were excluded. A total of 5 studies met the inclusion criteria for the systematic review and meta-analysis. The PRISMA flow diagram of the article selection process is shown in Figure 2.

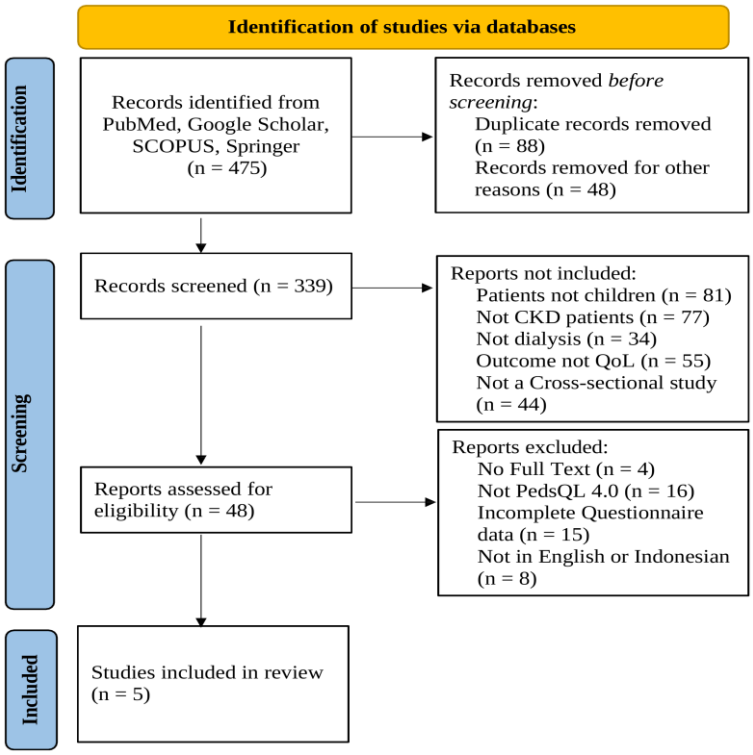

Figure 2. PRISMA flow diagram

Quality Assessment

Study quality was assessed using the ROBINS-E tool. In the ROBINS-E assessment, studies were evaluated across 7 domains (confounding, measurement of the exposure, selection of participants, post-exposure interventions, missing data, measurement of the outcome, and selection of the reported result) and received one of 3 ratings (low risk, some concerns, or high risk). The 7 domains of the five cross-sectional studies were assessed using ROBINS-E and are presented as a traffic-light plot in Figure 3.

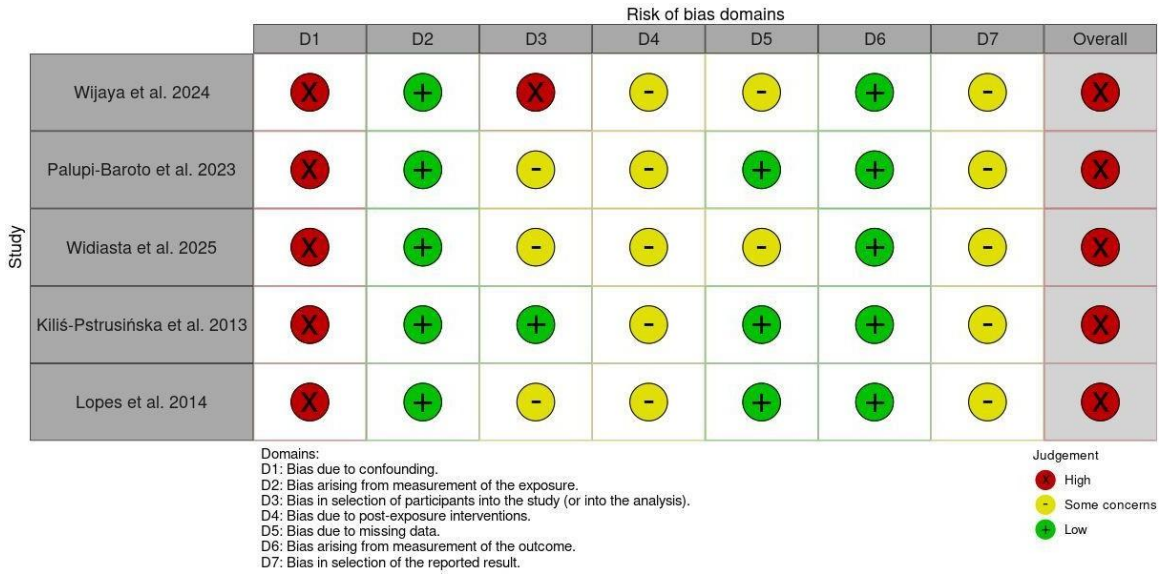

Figure 3. Traffic-light plot of the study quality assessment

Data Extraction

This systematic review and meta-analysis involved a total of 142 patients and 154 primary caregivers from 5 cross-sectional studies published between 2013 and 2025. There

were 73 patients undergoing hemodialysis with 75 primary caregivers and 69 patients undergoing peritoneal dialysis with 79 primary caregivers. All included studies reported questionnaire scores from 0 to 100 for each aspect (physical, emotional, social, and school) from both parties (children and primary caregivers). The characteristics of the studies are presented in Table 3.

Table 3. Characteristics of the included studies

Author	Year	Study design	Total HD population	Total PD population	Available data
Wijaya et al.	2024	Cross-sectional	34	4	Mean, SD
Palupi-Baroto et al.	2023	Cross-sectional	20	20	Mean, SD
Widiasta et al.	2025	Cross-sectional	24	26	Mean, SD
Kiliś-Pstrusińska et al.	2013	Cross-sectional	46	72	Median, IQR
Lopes et al.	2014	Cross-sectional	24	26	Median, IQR

Child Self-Report

For the physical aspect (Figure 4a), Wijaya et al. (2024) and Palupi-Baroto et al. (2023) found higher mean physical QoL scores among children receiving HD than among those receiving PD, with mean differences of 22.00 and 4.56 points, respectively. Conversely, Widiasta et al. (2025), Kiliś-Pstrusińska et al. (2013), and Lopes et al. (2014) reported higher physical QoL scores in the PD group, with mean differences of −27.35, −20.75, and −7.26 points, respectively. The overall mean difference was −7.52 (−23.74 to 8.71). The negative value indicates a tendency toward better physical QoL in the PD group; however, the 95% CI crossed zero, indicating that the difference was not significant, which was further supported by the test for overall effect ($p = 0.364$). The between-study variance was estimated at $Tau^2 = 250.53$, indicating considerable variability in the true effect size beyond sampling error. Cochran's Q test yielded $Chi^2 = 14.10$ with 4 df ($p = 0.007$), indicating high heterogeneity, and $I^2 = 71.6\%$ supported substantial heterogeneity.

For the emotional aspect (Figure 4b), Wijaya et al. (2024) and Lopes et al. (2014) found higher mean emotional QoL scores among children receiving HD, with mean differences of 13.00 and 6.66 points, respectively. Conversely, Palupi-Baroto et al. (2023), Widiasta et al. (2025), and Kiliś-Pstrusińska et al. (2013) reported higher emotional QoL scores in the PD group, with mean differences of −5.00, −5.38, and −12.11 points, respectively. The overall mean difference was −1.06 (−10.90 to 8.77), indicating a tendency toward better emotional QoL in the PD group; however, the 95% CI crossed zero and the test for overall effect yielded $p = 0.832$. The between-study variance was $Tau^2 = 53.69$, indicating moderate variability. Cochran's Q test yielded $Chi^2 = 14.10$ with 4 df ($p = 0.144$), indicating no statistically significant evidence that the observed differences among study results were greater than expected by chance, and $I^2 = 41.6\%$ supported moderate heterogeneity.

For the social aspect (Figure 4c), Wijaya et al. (2024) and Palupi-Baroto et al. (2023) found higher mean social QoL scores among children receiving HD, with mean differences of 42.00 and 9.50 points, respectively. Conversely, Widiasta et al. (2025), Kiliś-Pstrusińska et al. (2013), and Lopes et al. (2014) reported higher social QoL scores in the PD group, with mean differences of −12.53, −4.30, and −6.61 points, respectively. The overall mean difference was 3.04 (−13.17 to 19.25). The positive value indicates a tendency toward better social QoL in the HD group; however, the 95% CI crossed zero and the test for overall effect yielded $p = 0.713$.

The between-study variance was Tau² = 222.12, indicating considerable variability. Cochran's Q test yielded Chi² = 10.86 with 4 df (p = 0.028), indicating high heterogeneity, and a value of 63.2% supported substantial heterogeneity.

For the school aspect (Figure 4d), Wijaya et al. (2024), Palupi-Baroto et al. (2023), and Lopes et al. (2014) found higher mean school QoL scores among children receiving HD, with mean differences of 18.00, 21.50, and 9.14, respectively. Conversely, Widiasta et al. (2025) and Kiliś-Pstrusińska et al. (2013) reported higher school QoL scores in the PD group, with mean differences of −25.65 and −16.21 points, respectively. The overall mean difference was −0.16 (−19.49 to 19.17), indicating a tendency toward better school QoL in the PD group; however, the 95% CI crossed zero and the test for overall effect yielded p = 0.987. The between-study variance was Tau² = 383.37. Cochran's Q test yielded Chi² = 28.17 with 4 df (p = 0.0001), indicating high heterogeneity, and I² = 85.8% supported substantial heterogeneity.

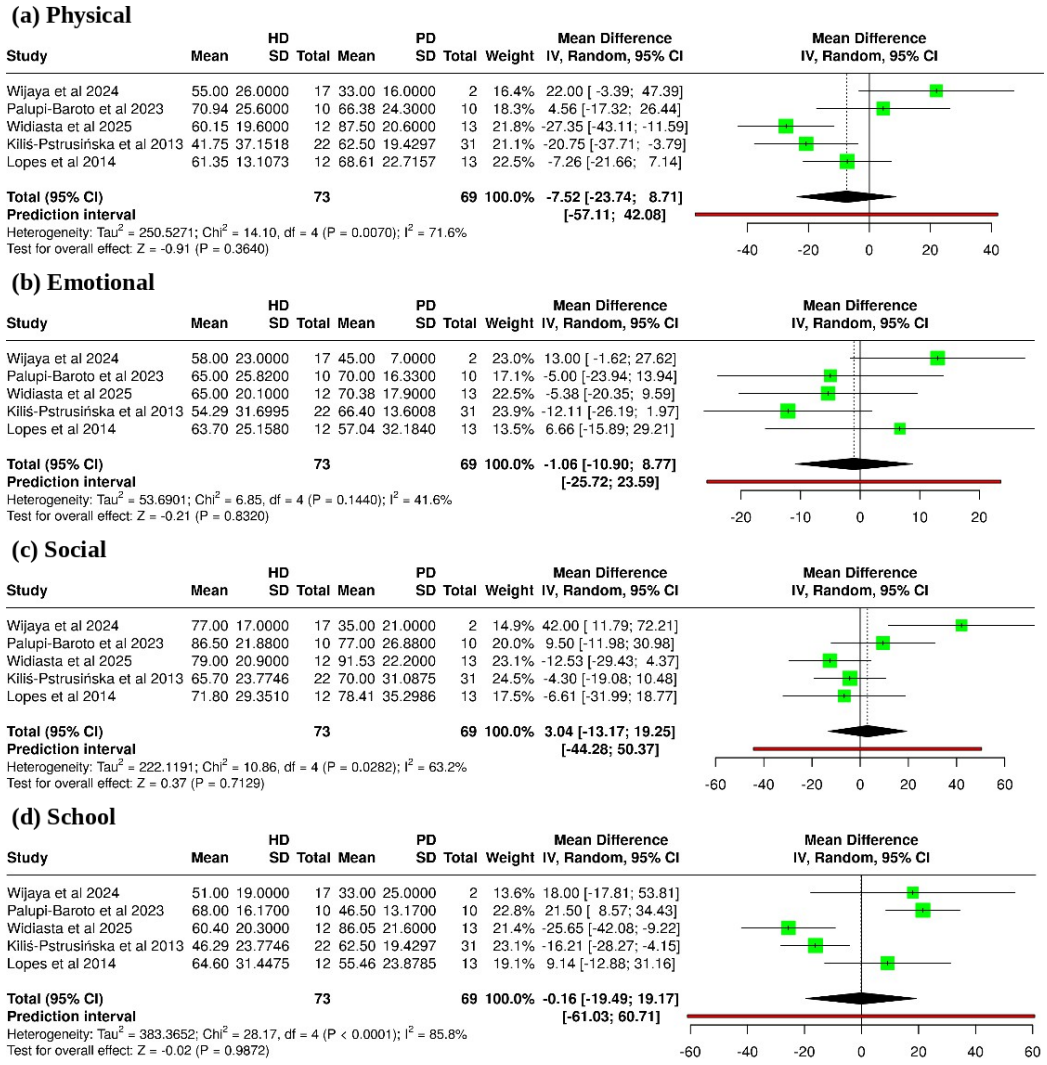

Figure 4. Forest plots of child self-reported HRQOL: (a) physical, (b) emotional, (c) social, and (d) school domains

Parent Proxy-Report

For the physical aspect (Figure 5a), Wijaya et al. (2024) and Palupi-Baroto et al. (2023) found higher mean physical QoL scores among children receiving HD, with mean differences of 12.00 and 13.12 points, respectively. Conversely, Widiasta et al. (2025), Kiliś-Pstrusińska

et al. (2013), and Lopes et al. (2014) reported higher physical QoL scores in the PD group, with mean differences of −17.96, −6.40, and −8.07 points, respectively. The overall mean difference was −4.40 (−16.14 to 7.35), indicating a tendency toward better physical QoL in the PD group; however, the 95% CI crossed zero and the test for overall effect yielded p = 0.463. The between-study variance was $Tau^2 = 75.34$, indicating moderate variability. Cochran's Q test yielded $Chi^2 = 6.91$ with 4 df (p = 0.141), and $I^2 = 42.1\%$ supported moderate heterogeneity.

For the emotional aspect (Figure 5b), Wijaya et al. (2024) found a higher mean emotional QoL score among children receiving HD, with a mean difference of 8.00. Conversely, Palupi-Baroto et al. (2023), Widiasta et al. (2025), Kiliś-Pstrusińska et al. (2013), and Lopes et al. (2014) reported higher emotional QoL scores in the PD group, with mean differences of −5.00, −4.07, −4.10, and −14.67 points, respectively. The overall mean difference was −3.54 (−9.88 to 2.81), indicating a tendency toward better emotional QoL in the PD group; however, the 95% CI crossed zero and the test for overall effect yielded p = 0.274. The between-study variance was $Tau^2 = 0$, indicating no between-study variability. Cochran's Q test yielded $Chi^2 = 2.21$ with 4 df (p = 0.697), and $I^2 = 0\%$ supported the absence of heterogeneity.

For the social aspect (Figure 5c), Wijaya et al. (2024), Palupi-Baroto et al. (2023), Widiasta et al. (2025), and Kiliś-Pstrusińska et al. (2013) found higher mean social QoL scores among children receiving HD, with mean differences of 9.00, 10.00, 4.00, and 9.29 points, respectively. Conversely, Lopes et al. (2014) reported a higher social QoL score in the PD group, with a mean difference of −4.40 points. The overall mean difference was 6.52 (−2.06 to 15.11), indicating a tendency toward better social QoL in the HD group; however, the 95% CI crossed zero and the test for overall effect yielded p = 0.1364. The between-study variance was $Tau^2 = 0$. Cochran's Q test yielded $Chi^2 = 0.89$ with 4 df (p = 0.9263), and $I^2 = 0\%$ supported the absence of heterogeneity.

For the school aspect (Figure 5d), Wijaya et al. (2024), Palupi-Baroto et al. (2023), and Lopes et al. (2014) found higher mean school QoL scores among children receiving HD, with mean differences of 17.00, 18.00, and 16.46, respectively. Conversely, Widiasta et al. (2025) and Kiliś-Pstrusińska et al. (2013) reported higher school QoL scores in the PD group, with mean differences of −27.00 and −9.60 points, respectively. The overall mean difference was 3.71 (−13.33 to 20.74), indicating a tendency toward better school QoL in the HD group; however, the 95% CI crossed zero and the test for overall effect yielded p = 0.6698. The between-study variance was $Tau^2 = 324.1495$. Cochran's Q test yielded $Chi^2 = 31.40$ with 4 df ($p < 0.0001$), indicating high heterogeneity, and $I^2 = 87.3\%$ supported substantial heterogeneity.

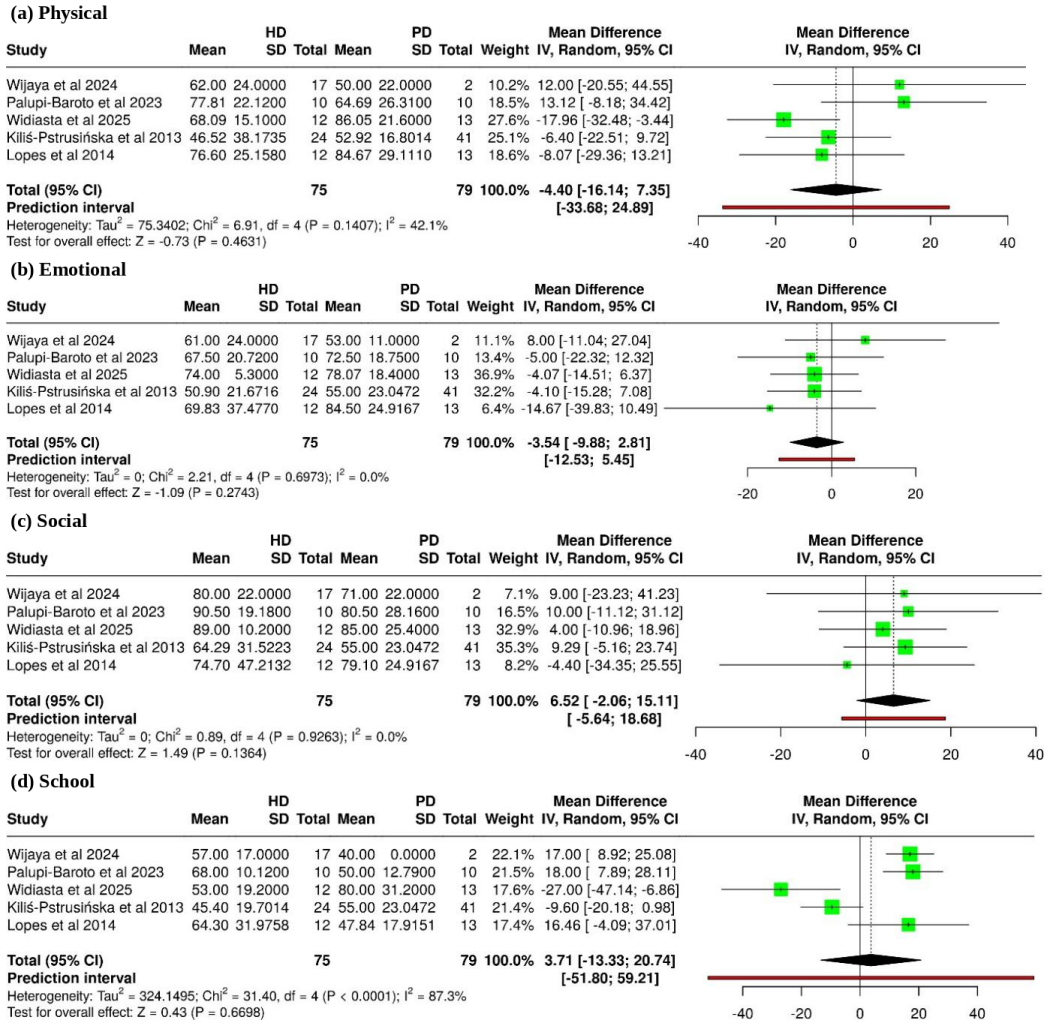

Figure 5. Forest plots of parent proxy-reported HRQOL: (a) physical, (b) emotional, (c) social, and (d) school domains

Physical Aspect of Quality of Life

This meta-analysis showed no statistically significant difference in physical HRQOL between children with CKD receiving HD and those receiving PD. Although the pooled MD indicated a tendency toward better physical QoL among children undergoing PD, the observed difference was not statistically significant. This finding suggests that dialysis modality is likely not the main determinant of physical functioning in pediatric CKD. Instead, physical QoL is influenced by various clinical and demographic factors, including CKD severity, nutritional status, anemia, growth disorders, comorbidities, treatment burden, and dialysis adequacy, all of which substantially affect children's physical functioning regardless of the dialysis modality used (Becherucci et al., 2016; Díaz-González de Ferris et al., 2021; VanSickle & Warady, 2022). This finding is consistent with previous systematic reviews showing that pediatric CKD is associated with reduced physical QoL compared with healthy children, while differences between dialysis modalities remain inconsistent across studies (Doshi et al., 2024; Ruidiaz-Gómez & Higuita-Gutiérrez, 2020).

The small trend favoring PD may be explained by several clinical advantages of home-based peritoneal dialysis. PD provides continuous solute and fluid removal, resulting in greater hemodynamic stability, fewer episodes of intradialytic hypotension, and better preservation of

residual kidney function than intermittent HD (Cho, 2020; VanSickle & Warady, 2022). Children receiving PD also avoid repeated vascular punctures, prolonged hospital visits, and the post-dialysis fatigue commonly experienced by patients on HD, potentially increasing participation in daily physical activities. However, PD is also associated with complications such as peritonitis, catheter malfunction, abdominal discomfort, dialysate leakage, and hernia, which may negatively affect physical functioning and reduce its potential benefits (Chadha et al., 2009; Marie et al., 2022; Prakash et al., 2011; Wisanuyotin et al., 2020). Conversely, advances in pediatric HD, including improved dialysis technology, individualized prescriptions, and multidisciplinary supportive care, have reduced treatment-related complications and may explain why some included studies reported better physical scores among HD recipients (Cho, 2020; Shin et al., 2015). Consequently, the inherent advantages and disadvantages of each dialysis modality likely contribute to the absence of a significant overall difference.

Substantial heterogeneity was observed in the child self-report analysis, whereas only moderate heterogeneity was present in the parent proxy-report analysis. This variability reflects important differences among the included studies, including patient age, CKD etiology, dialysis duration, socioeconomic background, health care resources, sample size, and national clinical practices. Children treated in developing countries face additional barriers related to limited health care access, malnutrition, transportation difficulties, and financial constraints that adversely affect physical QoL regardless of dialysis modality (Chaichana et al., 2024; Fibrianto et al., 2023). Although parent proxy-reports produced pooled estimates similar to child self-reports, parents generally reported slightly smaller differences between dialysis modalities, indicating greater consistency. Parents often evaluate observable limitations such as fatigue, mobility, exercise tolerance, and the ability to perform daily activities, whereas children may base their responses more on subjective symptoms, treatment experiences, and adaptation to chronic illness (Toro-Pérez et al., 2023; Varni & Limbers, 2009). Previous studies have shown moderate agreement between child and parent reports on physical functioning, although parents often underestimate or overestimate aspects of their child's QoL depending on caregiver stress and family circumstances (Ong et al., 2021; Tjaden et al., 2015; Tong et al., 2008).

Emotional Aspect of Quality of Life

This meta-analysis found no statistically significant difference in emotional HRQOL between children with CKD undergoing HD and those receiving PD, based on either child self-reports or parent proxy-reports. Although the pooled estimates showed a slight tendency toward better emotional QoL among children treated with PD, the p-values indicated that dialysis modality was not significantly associated with differences in emotional functioning. Emotional well-being in pediatric CKD is influenced by various factors, including disease duration, prognostic uncertainty, repeated hospitalizations, treatment adherence, and restriction of normal activities (Becherucci et al., 2016; VanSickle & Warady, 2022). Previous systematic reviews also reported that children with advanced CKD experience much poorer emotional QoL than healthy children, while evidence comparing HD and PD remains inconclusive (Doshi et al., 2024; Ruidiaz-Gómez & Higuita-Gutiérrez, 2020).

The slight trend favoring PD may be explained by the greater flexibility provided by home-based dialysis, which allows children to remain in a familiar family environment and

maintain more consistent daily routines. Compared with HD, PD reduces the need for frequent hospital visits and minimizes disruption to family life, factors that may reduce anxiety and emotional distress (Cho, 2020; VanSickle & Warady, 2022). However, PD also places considerable responsibility on children and caregivers, potentially increasing psychological stress (Chadha et al., 2009; Ong et al., 2021). Children undergoing HD initially experience anxiety related to needle insertion and long dialysis sessions, but comprehensive support, adaptation over time, and routine interaction with health care workers can help reduce emotional distress and improve emotional QoL in the HD group (Shin et al., 2015; Tjaden et al., 2015).

Emotional outcomes showed relatively low between-study variability, with moderate heterogeneity for child self-reports and no heterogeneity for parent proxy-reports. These findings indicate greater consistency regarding the emotional effects of dialysis regardless of geographic location or health care system. Emotional adaptation among children with CKD follows similar patterns across populations because common psychosocial stressors are experienced by patients regardless of dialysis modality (Dotis et al., 2016; WHO, 2012). The absence of heterogeneity in parent proxy-reports further suggests that caregivers consistently perceive emotional functioning in children undergoing HD and PD as largely comparable, strengthening the robustness of the pooled estimate. Children and parents showed similar pooled effects favoring PD, although parents generally perceived slightly greater emotional disadvantages than children. This difference has been reported previously and reflects differing perspectives: children gradually adapt to chronic illness and normalize their emotional experiences, whereas parents remain more aware of long-term consequences (Toro-Pérez et al., 2023; Varni & Limbers, 2009). Parents of children receiving dialysis often report persistent psychological distress, caregiver burden, anxiety, and concerns about disease progression, factors that may influence their assessment of their child's emotional well-being (Ong et al., 2021; Tong et al., 2008).

Social Aspect of Quality of Life

This meta-analysis showed no statistically significant difference in social HRQOL between children with CKD receiving HD and those undergoing PD based on child self-reports or parent proxy-reports. Child self-reports showed a slight tendency toward better social functioning among children in the HD group, and parent proxy-reports showed a similar but stronger trend; however, neither analysis was significant. These findings suggest that the choice of dialysis modality does not substantially affect children's social QoL. Instead, social functioning is shaped by many interrelated factors, including family support, peer relationships, school participation, socioeconomic status, self-esteem, physical limitations, and opportunities for age-appropriate social interaction (Didsbury et al., 2016; Dotis et al., 2016; You et al., 2022). Previous systematic reviews concluded that children with CKD generally experience poorer social QoL than healthy peers, although evidence comparing HD and PD remains inconsistent and insufficient to establish the superiority of either modality (Doshi et al., 2024; Ruidiaz-Gómez & Higuita-Gutiérrez, 2020).

The trend favoring HD reflects several practical aspects that facilitate social interaction. Children receiving HD routinely visit dialysis centers several times each week, providing regular opportunities to interact with health care workers and other children undergoing similar treatment. Repeated social encounters can foster peer support, reduce feelings of isolation, and

strengthen coping strategies through shared experiences. In contrast, children receiving PD often perform dialysis at home, allowing greater independence and flexibility but potentially limiting opportunities for face-to-face interaction with peers who have similar health conditions (Cho, 2020; Shin et al., 2015). PD also allows children to spend more time with family members and participate in community activities by avoiding frequent hospital visits, which may increase social participation. Consequently, the social advantages associated with HD and PD offset each other. Furthermore, social well-being is influenced by various factors beyond dialysis modality (Bonyan, 2023; Kallander et al., 2020).

Substantial heterogeneity was found in the child self-report analysis, whereas no heterogeneity was observed in the parent proxy-report analysis. The considerable variability among children's responses likely reflects differences in age, personality, cultural background, opportunities for social participation, health care infrastructure, and educational support across the included studies. Differences in family socioeconomic status and access to psychosocial services may also affect children's ability to participate in recreational and community activities despite chronic illness (Chaichana et al., 2024; Didsbury et al., 2016). Both child and parent assessments showed a slight advantage for HD, with parents generally perceiving greater improvement in social functioning than children themselves. This difference may arise because parents often evaluate social participation based on observable behavior, whereas children assess their own experiences on a more subjective basis (Toro-Pérez et al., 2023; Varni & Limbers, 2009).

School Aspect of Quality of Life

This meta-analysis found no statistically significant difference in school-related HRQOL between children with CKD receiving HD and those undergoing PD based on child self-reports or parent proxy-reports. Although child self-reports showed a marginal tendency toward better school functioning among children receiving PD, while parent proxy-reports slightly favored HD, both pooled estimates were close to zero. These findings suggest that school functioning is influenced more by the overall burden of CKD than by dialysis modality. Children receiving HD or PD generally experience frequent medical visits, hospitalizations, fatigue, cognitive impairment, absenteeism, and difficulty maintaining academic achievement, all of which negatively affect school participation regardless of treatment modality (Becherucci et al., 2016; VanSickle & Warady, 2022). In addition, anemia, metabolic disorders, sleep disturbances, and neurocognitive deficits can impair attention, memory, and learning ability, further reducing educational attainment (Dotis et al., 2016; KDIGO, 2024). Previous systematic reviews also reported that school functioning is among the most impaired HRQOL domains in pediatric CKD and that current evidence does not support a clear advantage of HD or PD (Doshi et al., 2024; Ruidiaz-Gómez & Higuita-Gutiérrez, 2020).

Large heterogeneity was observed in both child self-reports and parent proxy-reports, indicating considerable variability among the included studies. This heterogeneity likely reflects differences in educational systems, access to home-based or hospital-based schooling, dialysis duration, socioeconomic conditions, and health care resources across countries. Variability in the availability of educational support services, family involvement, and school accommodations may also contribute to the inconsistent findings across studies. Both perspectives consistently indicate that dialysis modality is not the main determinant of educational QoL. Children often evaluate school functioning based on their own experiences

of learning, concentration, peer interaction, and academic participation, whereas parents may place more emphasis on school attendance and observable academic performance (Toro-Pérez et al., 2023; Varni & Limbers, 2009). The difference between these perspectives likely reflects differences in how children and caregivers understand the educational consequences of chronic illness rather than true differences between dialysis modalities.

Study Limitations

This meta-analysis has several limitations. First, only five cross-sectional studies met the inclusion criteria, resulting in a relatively small sample size and limiting statistical power. Second, substantial heterogeneity was observed in several domains because of differences in participant characteristics, dialysis duration, health care settings, and patient backgrounds across studies. Third, all included studies were observational, preventing the establishment of a causal relationship between dialysis modality and quality of life. Finally, only one generic questionnaire was used. Therefore, the findings should be interpreted with caution, and further prospective multicenter studies with larger sample sizes using more specific measurement instruments are needed to provide stronger evidence regarding the impact of HD and PD on the quality of life of children with CKD.

CONCLUSION

This meta-analysis found no statistically significant differences in health-related quality of life (HRQoL) between children with chronic kidney disease (CKD) undergoing hemodialysis (HD) and those receiving peritoneal dialysis (PD) across the physical, emotional, social, and school functioning domains, based on either child self-reports or parent-proxy reports. Although the pooled estimates tended to favor PD in the physical and emotional functioning domains and HD in the social functioning domain, these differences were not statistically significant. In the school functioning domain, child self-reports tended to favor PD, whereas parent-proxy reports tended to favor HD. These findings suggested that the available evidence did not establish a clear HRQoL advantage for either dialysis modality. Therefore, dialysis modality selection should be individualized, considering clinical indications, treatment requirements, children's psychological and educational needs, family circumstances, caregiver support, peer relationships, opportunities for social participation, and patient and family preferences. Particular attention should be given to treatment schedules and caregiving demands, as these factors may influence school attendance and participation in daily activities.

Future research should involve larger, prospective, multicenter studies with appropriate adjustment for potential confounding factors, including age, disease severity, comorbidities, dialysis duration, and socioeconomic characteristics. Standardized use of validated HRQoL instruments, particularly the Pediatric Quality of Life Inventory™ (PedsQL™) 4.0 Generic Core Scales, would improve comparability across studies and facilitate more robust meta-analyses. When different instruments are used, validated score harmonization methods or standardized effect sizes should be considered where appropriate. Further investigation of treatment-related, psychosocial, and family factors is also recommended to clarify the relationships between dialysis modality and HRQoL outcomes among children with CKD.

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CONFLICT OF INTEREST

The authors declare that this research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

AUTHOR CONTRIBUTIONS

All authors contributed to the preparation and writing of this article.

GENERATIVE AI STATEMENT

In the preparation of this manuscript, the authors utilized Artificial Intelligence (AI) solely for the purposes of improving grammar and checking language usage.

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