

Hemodialysis Adequacy in Iraq: A Comprehensive Systematic Review and Meta-Summary of Regional Variations, Determinants, and Clinical Implications (2011–2025)

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Abstract

Background: The adequacy of hemodialysis is a vital indicator of treatment quality and patient survival among individuals with end-stage renal disease. In Iraq, regional disparities and inconsistent monitoring have limited the understanding of dialysis performance and its determinants.

Aim of the Study: To assess the adequacy of hemodialysis across Iraq from 2011 to 2025, focusing on regional variations, contributing factors, and related clinical outcomes.

Subjects and Method: A systematic review and meta-summary were conducted according to the 2020 Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines. Eight eligible studies from Baghdad, Erbil, Karbala, Najaf, Diyala, Sulaimani, Basra, and national multicenter data were analyzed. Owing to differences in study design and reporting, data were synthesized narratively. Hemodialysis adequacy was defined as a single-pool Kt/V of at least 1.2 or a urea reduction ratio of 65 percent or higher.


Results: Adequacy rates ranged from 28.6 to 73 percent, with dialysis centers in Erbil achieving higher levels than those in other cities. Determinants of adequacy included longer session duration, higher blood flow rate, and the use of arteriovenous fistulas. Adequate dialysis was associated with higher hemoglobin levels, better biochemical and nutritional parameters, fewer hospitalizations, and improved quality of life. The mean adequacy of hemodialysis, excluding Erbil city hemodialysis centers, was 41.7%.

Conclusion: Hemodialysis adequacy in Iraq remains below international standards. Strengthening infrastructure, standardizing national protocols, and establishing a national dialysis registry are essential to improve dialysis quality and patient outcomes.

Keywords: End-Stage Renal Disease, Hemodialysis Efficacy, Hemodialysis Outcomes

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Introduction

Chronic kidney disease (CKD) is a growing public health problem in Iraq. This is similar to what is happening around the world, but it is worse because of problems with the region's health system. The prevalence of chronic kidney disease (CKD) is rising

due to the increasing incidence of glomerulonephritis, diabetes mellitus, hypertension, and other chronic renal disorders.¹ These diseases progressively impair renal function, ultimately resulting in end-stage renal disease (ESRD), at which stage renal replacement therapy becomes essential for patient survival. Hemodialysis (HD) is the most common and easiest way to get treatment in

Iraq, and both public and private healthcare facilities offer it.^{2,3} There are major HD centers in major Iraqi cities such as Baghdad, Basra, Karbala, Najaf, Erbil, Diyala, and Sulaimani. This shows that the government is trying to ensure that everyone can reach them, even though it is tough to do so.⁴

Effective hemodialysis is necessary for the removal of uremic toxins, maintenance of fluid and electrolyte balance, prevention of cardiovascular complications, reduction of hospitalization rates, and improvement of overall patient quality of life. Dialysis adequacy is typically evaluated through standardized metrics such as Kt/V and the urea reduction ratio (URR). Kt/V is a measure of dialysis adequacy that reflects how effectively hemodialysis removes urea from the blood. It is calculated by multiplying the dialyzer's urea clearance (K) by the duration of the dialysis session (t) and dividing by the patient's total body water (V). The Urea Reduction Ratio (URR) is a measure of dialysis adequacy that reflects the percentage reduction in blood urea nitrogen (BUN) during a dialysis session. It is calculated by comparing pre-dialysis and post-dialysis BUN levels. Higher URR values indicate more effective removal of uremic toxins, with a value of $\geq 65\%$ generally considered adequate. Lower URR values suggest insufficient dialysis, which can contribute to complications such as Restless Legs

Syndrome. These figures provide objective assessments of solute removal efficiency during dialysis sessions. The Kidney Disease Outcomes Quality Initiative (KDOQI) and the European Renal Association (ERA-EDTA) say that hemodialysis is adequate if the single-pool Kt/V (spKt/V) is at least 1.2 per session or if the urea reduction ratio (URR) is 65% or higher for patients who get hemodialysis three times a week.¹⁻⁵

International studies furnish substantial evidence of a significant correlation between dialysis adequacy and critical clinical outcomes, including survival, cardiovascular morbidity, anemia management, and nutritional status.^{6,7} Insufficient dialysis leads to dire consequences, such as starvation, persistent uremic symptoms, anemia, diminished responsiveness to erythropoietin-stimulating agents (ESAs), increased hospitalization rates, and heightened mortality.⁸

Despite the recognized importance of dialysis adequacy, hemodialysis in Iraq faces several challenges. The number of dialysis machines often isn't enough to accommodate the growing number of patients, which means more patients per machine and shorter sessions. Staffing shortages, inconsistent scheduling, limited access to qualified nephrology specialists, and an uneven geographic distribution of dialysis facilities exacerbate service inequities.⁹

Additionally, patient-related factors, including comorbidities, nutritional status, type of vascular access, adherence to treatment regimens, and socioeconomic constraints, significantly influence the efficacy of HD therapy.¹⁰

Research published from various regions of Iraq highlights considerable disparities in dialysis adequacy. Evaluations in Baghdad and Najaf reveal inadequate Kt/V and URR values, underscoring systemic deficiencies and high incidences of malnutrition (no dietitian consultations), comorbidities, and vascular access complications (malfunction of vascular access).^{1,4}

On the other hand, data from Erbil, Sulaimani, and parts of Karbala show that targeted treatments, such as adjusting the blood flow rate, lengthening session time, scheduling sessions in the morning, and providing dietary advice, can significantly improve dialysis adequacy and patient outcomes.^{2,3,7,9}

This difference between regions shows how important it is to carefully combine all the evidence to determine what makes dialysis effective, how to improve clinical practice, and how to change health policy in Iraq.

Understanding the regional patterns of HD adequacy and identifying modifiable factors are essential for improving patient-centered outcomes, guiding resource allocation, and establishing standardized treatment protocols in Iraq.

A comprehensive evaluation of both published and gray literature (not published in traditional journals) is necessary to capture the current state of hemodialysis efficacy, identify treatment deficiencies, and offer pragmatic recommendations for clinicians, policymakers, and healthcare organizations.¹⁻⁸

Given the importance of dialysis adequacy for patients undergoing hemodialysis, evaluating dialysis effectiveness and adequacy in this study would help policymakers and healthcare professionals reassess and, if necessary, revise their current practices to improve dialysis outcomes.

Many studies have been done in different parts of Iraq to find out how well patients on hemodialysis are doing with their dialysis. However, there is still no complete estimate of how well dialysis is working in Iraq. Also, it hasn't been clear in recent years how well dialysis works in Iraq in general.

This study aimed to evaluate the adequacy of dialysis in patients undergoing hemodialysis in Iraq through a systematic review and meta-analysis.

Patients and Methods

We conducted this study as a systematic review and narrative meta-summary to assess the effectiveness and appropriateness of hemodialysis (HD) in Iraq. The method followed the 2020 guidelines of the Preferred Reporting

Items for Systematic Reviews and Meta-Analyses

(PRISMA) to ensure transparency and reproducibility.

Because the studies included varied in design, sample size, and outcome reporting, a formal meta-analysis was not feasible. A structured narrative synthesis methodology was used to synthesize findings and identify the principal factors influencing dialysis adequacy across diverse regions of Iraq.

A comprehensive literature review was performed using various electronic and regional resources, including PubMed, Google Scholar, ResearchGate, and Iraqi medical journals such as the Iraqi Journal of Medical Sciences, Annals of Tropical Medicine & Public Health, Journal of Sulaimani Medical College, and Zanco Journal of Medical Sciences. Also, relevant conference proceedings and postgraduate theses were reviewed to identify unpublished data or gray literature. The search included studies published between January 2011 and October 2025. A mix of MeSH phrases and free-text keywords was used, such as "hemodialysis," "dialysis adequacy," "Kt/V," "urea reduction ratio," "URR," "end-stage renal disease," "ESRD," "renal replacement therapy," "Iraq," "quality of life," and "adherence." Boolean operators such as AND and OR were used to narrow results (e.g., "hemodialysis AND Iraq AND adequacy"). The reference lists of all the publications

found were also reviewed by hand to identify additional studies not in the databases. The following criteria made studies eligible for inclusion: (1) conducted in Iraq from 2011 to 2025; (2) included adult patients aged 18 years or older diagnosed with end-stage renal disease (ESRD) and undergoing chronic hemodialysis; (3) reported quantitative measures of dialysis adequacy, including single-pool Kt/V or urea reduction ratio (URR); and (4) provided data on one or more relevant clinical parameters such as dialysis session duration, frequency, vascular access type, comorbidities, nutritional status, anemia control, treatment adherence, or quality of life. Studies were excluded if they involved children or teenagers (<18 years), were case reports, letters to the editor, or reviews without primary data, were conducted outside of Iraq, or lacked clear adequacy measures such as Kt/V or URR. Two reviewers independently extracted and synthesized the data, checking all titles and abstracts to determine eligibility. We discussed the differences between the reviewers and reached an agreement. We identified and thoroughly analyzed full-text articles that met the inclusion criteria. The information extracted was entered into a standard Excel data extraction form. The extracted variables included bibliographic details (author names, publication year, and study region), demographic data (sample size, age range, and sex distribution), dialysis

parameters (session duration in hours, weekly frequency, type of vascular access—arteriovenous fistula, graft, or catheter—blood and dialysate flow rates, and total treatment duration in months or years on HD), adequacy indicators (single-pool Kt/V calculated using the Daugirdas formula and URR percentage calculated as $[(\text{pre-HD BUN} - \text{post-HD BUN})/\text{pre-HD BUN}] \times 100$), laboratory and clinical indicators (serum albumin, hemoglobin, calcium, phosphorus, and parathyroid hormone levels), and patient-related factors including nutritional assessment scores, adherence indicators, and quality-of-life (QOL) measures where applicable.

The efficacy of dialysis in each study was evaluated by comparing the reported Kt/V and URR values to the adequacy standards set forth by the Kidney Disease Outcomes Quality Initiative (KDOQI) guidelines. A dialysis session is considered sufficient when the Kt/V is at least 1.2 and the URR is at least 65%. Studies showing mean adequacy values above these levels were considered "adequate," and those showing values below them were considered "inadequate."

Because the study populations and methods differed, a narrative synthesis was used rather than a pooled meta-analysis. Data were structured and analyzed to enable regional comparisons among Iraqi cities, including Baghdad, Diyala, Karbala, Najaf, Erbil, Duhok,

Sulaimani, Mosul, Nasiriyah, and Basra (in a multicenter study). The analysis identified key factors affecting dialysis adequacy, including session duration, vascular access type, comorbidity burden, anemia management, nutritional considerations, and treatment adherence. Longitudinal data were examined to evaluate trends in dialysis efficacy over time, accounting for modernization of dialysis units and improvements in staff training programs. We used descriptive statistics, including mean \pm standard deviation (SD), medians, and ranges, to summarize the data.

The selection of studies was documented in accordance with PRISMA 2020 standards. There were 84 records found in all through searches of databases and gray literature. After removing 12 duplicates, 72 unique records remained. After reviewing the titles and abstracts, 32 full-text articles were selected for further review. Eight studies met all of the requirements and were included in the final synthesis.

We used the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) checklist to assess the methodological quality of all the studies we reviewed. This tool is widely used to check the design of observational studies, the rigor of their methods, and the openness of their reports. This makes sure that the results of the current review are reliable.¹⁰⁻¹²

Results

Eight studies from 2011 to 2025 examined important areas of Iraq, including Baghdad, Erbil, Karbala, Najaf, Diyala, Sulaimani, Basra, and a few national studies conducted across multiple centers. Altogether, these studies included 1,115 patients who were on hemodialysis. All studies assessed dialysis adequacy, primarily using single-pool Kt/V and/or urea reduction ratio (URR). Some of them also looked at nutritional status, how well they managed anemia, comorbidities, and quality of life. In Iraq, the adequacy of dialysis varied a lot, with rates ranging from 28.6% to 73%. In Erbil, usually better results are achieved than in other cities (because of the longer duration of dialysis sessions).¹⁻⁸

Al-Saedy et al. (2011) conducted an early study in Baghdad involving 86 hemodialysis patients from 5 hospitals. They found that the average Kt/V was 1.02 ± 0.2 , which is below the recommended level of 1.2. Dialysis sessions lasted an average of 6.4 hours per week, with a standard deviation of 1.9 hours, and 63.5% of people were malnourished. Hepatitis B and C infections affected 43% of patients, and many of them also had other health problems like diabetes and high blood pressure. Only 14% of them were working, indicating they couldn't function physically or socially.¹ A recent study by Mohammed et al. (2024) examined 100 patients in

Baghdad receiving hemodialysis. They found that 42% of cases had consistently low delivered dialysis doses below international adequacy standards. Not getting enough dialysis was strongly linked to being female, using temporary catheters, having shorter sessions, having a low BMI, and having multiple health problems at the same time.⁶

Saeed and Sinjari (2018) conducted a study in Erbil with 120 chronic HD patients, finding a mean URR of 68.3% and 73.3% of patients achieving adequate Kt/V, which is better than what is seen in most other areas. Adequacy improves with longer dialysis sessions, higher blood flow rates, and a three-session-per-week schedule. Patients without diabetes or hypertension, as well as those with arteriovenous fistula (AVF) access, demonstrated enhanced adequacy. Nutritional status and BMI were recognized as favorable predictors.^{2\}

Noori et al. (2022) analyzed 202 HD patients in Karbala and discovered that only 44.6% achieved adequate dialysis. Inadequate adequacy was correlated with advanced age, male gender, lower serum albumin levels, and higher phosphate levels. Shorter sessions and insufficient reuse of the dialyzer were two critical technical issues. The study underscored the importance of individualized treatment duration and of evaluating dialyzer efficacy.³

Al-Rubaia et al. (2022) assessed 174 hemodialysis patients in Najaf and found that only 35.1% achieved an adequate Kt/V, with a mean of 1.07. There was very little correlation with demographic variables, suggesting that systemic problems such as overcrowded centers, insufficient staff, and insufficient machines had a significant effect on dialysis outcomes.⁴

Athab (2017) assessed 70 HD patients in Diyala and found that 58.6% met the target adequacy. Gender and vascular access type were significant predictors; patients with arteriovenous fistulas (AVF) had greater adequacy than those using catheters. The study emphasized the imperative of diminishing long-term catheter dependence to enhance dialysis outcomes.⁵

Sharif et al. (2021) evaluated 213 patients across seven dialysis centers in Sulaimani. Of those patients, 61 (28.6%) had adequate dialysis. An interventional program that shifted dialysis sessions to morning shifts and added nutritional counseling increased the mean Kt/V from 1.20 to 1.54 and the URR from 59.96% to 71.21%.⁷

Ahmed et al. (2024) recently did a multicenter study with 150 patients from Baghdad, Erbil, and Basra. The results demonstrated a significant correlation between suboptimal Kt/V and erythropoietin-stimulating agent (ESA) hypo-responsiveness, thereby establishing a clinical link between dialysis dosage and anemia management. The

study underscored that dialysis adequacy should be regarded not solely as a biochemical metric but also as a determinant of clinical outcomes.⁸

A review of regional hemodialysis adequacy studies in Iraq reveals considerable variability in dialysis performance and patient outcomes among different governorates. Adequacy levels were higher in Erbil than in other cities, where they often fell below 50% (41.7% in this case). The adequacy was influenced by session duration, type of vascular access, nutritional status, and the presence of comorbidities. Interventional programs, particularly those focusing on prolonged session durations, AV fistulas, and patient education, markedly improved adequacy indices. These results show differences between regions and a need for standardized dialysis protocols and focused quality-improvement initiatives to improve patient outcomes nationwide. See Table 1 for more information.

Table 2 lists the factors that affect dialysis effectiveness, with a focus on those that influence hemodialysis in Iraq. Technical parameters, such as session duration, blood flow rate, and vascular access type, consistently proved to be the most critical indicators of adequacy. Higher Kt/V and URR values were associated with longer treatment times, higher blood flow rates, and the use of arteriovenous fistulae. Factors related to the patient, like

their nutritional status, comorbidities, and serum albumin levels, had a significant impact on adequacy outcomes. This shows that, in addition to technical optimization, holistic management is also essential. Some studies found differences between men and women, with women having slightly lower levels of adequacy. This could be because of differences in body size and access. Studies in Sulaimani demonstrate that organized counseling and patient education initiatives enhance adherence and overall dialysis efficacy, underscoring the need for integrated care models that encompass medical, technical, and educational interventions.

Table 3 shows the clinical factors affecting dialysis adequacy across different parts of Iraq. It includes the author, location, and main findings. Technical parameters, such as session duration, blood flow rate, and dialyzer type, significantly impact solute clearance. Longer sessions, higher flow rates, and high-efficiency dialyzers consistently improve Kt/V and URR. Factors about the patient, such as nutritional status, other health problems, and serum albumin or phosphorus levels, are very important for linking metabolic health to dialysis success.

Additionally, the type of vascular access and patient adherence are crucial modifiable factors, as the use of arteriovenous fistulas and regular attendance at sessions

significantly improve adequacy. Gender differences, especially the lower adequacy seen in females, point to both physiological and procedural differences. Research from various centers and regions, including studies by Ahmed et al. and Sharif et al., demonstrates a direct correlation among dialysis adequacy, erythropoietin responsiveness, and overall clinical outcomes. This underscores the imperative for a holistic approach that integrates technical enhancement, patient education, and tailored care strategies.

Table 4 presents the clinical outcomes associated with dialysis adequacy in hemodialysis patients in Iraq. This shows how important it is for patient prognosis. Adequate dialysis, as evidenced by elevated Kt/V and URR values, exhibits substantial positive correlations with improved hemoglobin levels, nutritional status, and serum albumin, while simultaneously reducing phosphorus accumulation and uremic burden. The results show that receiving adequate dialysis helps control blood pressure, reduces hospital stays, and improves overall quality of life, especially mental and physical health. Furthermore, adequate dialysis improves erythropoietin responsiveness, significantly lowers serum creatinine and urea levels, and decreases inflammatory markers such as CRP, all of which suggest better systemic and metabolic balance. Insufficient dialysis correlates with increased morbidity

and mortality, underscoring the necessity of adhering to optimal adequacy standards to enhance survival and long-term outcomes in Iraqi hemodialysis populations.

Discussion

The average percentage of adequate HD in other centers across Iraq was 41.7% excluding the Erbil HD center. The results of this review indicate that dialysis adequacy among hemodialysis patients in Iraq is influenced by various modifiable and non-modifiable factors, with systemic healthcare limitations being a significant determinant. Iraqi studies consistently identify session duration, frequency, blood flow rate, and type of vascular access (e.g., arteriovenous fistula vs. catheter) as significant determinants of achieving target adequacy (e.g., $Kt/V \geq 1.2$ or $URR \geq 65\%$).¹⁻⁸ Non-modifiable factors, such as advanced age, heightened comorbidity burden (particularly diabetes and hypertension), and compromised nutritional status (e.g., hypoalbuminemia, low BMI), negatively influence adequacy and are consistently recorded.^{1,4,6,8}

The factors influencing both patients and treatments mirror trends seen in the Middle East and globally. A study in the Gulf Cooperation Council (GCC) region, comprising Bahrain, Kuwait, Oman, Qatar, Saudi Arabia,

and the UAE, found that only 34%–40% of hemodialysis (HD) patients achieved a $Kt/V \geq 1.2$. The results showed that shorter treatment times (less than 4 hours) and low blood flow rates (less than 350 mL/min) were significant factors in poor dialysis outcomes. As well as high patient body size, requiring more intensive dialysis. These factors highlight that even well-resourced systems can face challenges in achieving optimal dialysis adequacy.^{10,11} In a multicenter study in Iran involving 9,408 patients, the mean Kt/V was 1.11, below the target of 1.2. The average URR was about 59.9%. This finding is similar to what occurred in Iraq and shows that developing countries generally do not fare well.^{12,13}

The problems in Iraq as a whole make these individual issues worse. Dialysis centers are not always easy to get to in both cities and rural areas. There aren't enough staff members, there are too many patients per machine, and there isn't enough monitoring of adequacy metrics (Kt/V , URR). There isn't a centralized national dialysis registry, either. All of these factors make it hard to provide quality care consistently. Structural constraints align with other researchers' findings; a global review showed that countries with strong monitoring and registry systems have much better dialysis adequacy.⁹

Insufficient dialysis in Iraq has serious health effects, such as malnutrition, anemia, lower health-related quality of

life (HRQOL), heart problems, and a high rate of erythropoietin-stimulating agent (ESA) hypo-responsivity.^{1,4,6,8} Data from other places backs up this conclusion: a review from Europe found that lower Kt/V and URR were linked to higher death and hospitalization rates in HD populations around the world.¹⁴ A 2023 study found that higher URR (greater than 70%) and Kt/V (greater than 1.4) are associated with better survival. This shows how important it is for treatment to be adequate for patients to do well.⁹

Studies from Iraq and the region show that targeted interventions can significantly enhance dialysis effectiveness and improve patient outcomes. In Sulaimani, the shift to morning sessions and the introduction of structured nutritional counseling led to an increase in the mean Kt/V from 1.20 to 1.54 and the URR from about 60% to about 71%.⁷ Similar outcomes are observed in the international literature: a meta-analysis demonstrated that an elevation in dialysate flow rate significantly improved Kt/V by +0.08 and URR by +3.38 across various contexts.^{15,16} These interventions demonstrate that various obstacles to adequacy can be mitigated through efficient resource allocation, optimization of scheduling, and education for both patients and staff.

From this evidence, we can make several helpful suggestions. In Iraq, hemodialysis programs must follow

and enforce standardized protocols that are in line with established guidelines. For example, the Kidney Disease Outcomes Quality Initiative (KDOQI) says that a single-pool Kt/V of ≥ 1.2 (or higher if possible) and a URR of $\geq 65\%$ are acceptable. When planning vascular access, fistulas should come before catheters. Ensuring that sessions last long enough and happen often enough, that blood flow and dialysate flow rates are at their best, that nutritional assessments and interventions are done regularly, and that patients get help sticking to their treatment plan are all essential parts. A national dialysis registry at the system level would make it easier to keep track of adequacy, outcomes, and center-level performance. This would help with benchmarking and improving quality.

Multicenter interventional studies in the Iraqi context would also help tailor globally derived standards to local realities.

Conclusion

In Iraq, the quality of hemodialysis varies a lot from region to region. Several factors make dialysis less effective, including the patient's length of stay, flow rate, vascular access, nutrition, and other health problems. These are in addition to the issues that the health care system as a whole faces. Both local and international evidence show that achieving adequacy (e.g., Kt/V ≥ 1.2 or

URR $\geq 65\%$) is linked to higher survival rates, better anemia management, improved nutrition, and better overall quality of life. The use of targeted interventions, such as standardized protocols, improved scheduling, enhanced vascular access, nutritional and adherence support, and comprehensive data monitoring, is the best way to improve dialysis outcomes in Iraq. We need more research and well-organized national quality monitoring programs right away to help shape policy and practice.

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