



The Relationship Between Blood Flow Rate (QB) and Urea Reduction Ratio (Urr) and Uremic Pruritus in Patients With Chronic Kidney Failure Undergoing Hemodialysis at Harapan Anda University Hospital in Tegal

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Abstract

Background: Chronic kidney failure patients undergoing hemodialysis commonly experience uremic pruritus, which may be influenced by dialysis adequacy and technical parameters such as blood flow rate (QB) and Urea Reduction Ratio (URR). Objective: This study analyzed the relationships between QB, URR, and uremic pruritus among patients undergoing hemodialysis at Harapan Anda University Hospital in Tegal. Methods: A quantitative cross-sectional correlational design was applied to 52 respondents selected through purposive sampling. QB was obtained from hemodialysis machine records, URR was calculated from pre- and post-dialysis blood urea values, and pruritus was assessed using the 5-D Itch Scale. Results: Moderate QB was observed in 69.2% of respondents, while 69.2% had adequate URR. Moderate pruritus was the most frequent category (53.8%). QB was significantly and inversely associated with pruritus severity ($r = -0.493$; $p < .001$), as was URR ($r = -0.517$; $p < .001$). Conclusion: Better blood flow and dialysis adequacy were associated with lower uremic pruritus severity, supporting routine optimization of hemodialysis parameters alongside systematic symptom assessment. These findings emphasize integrated dialysis monitoring to improve treatment effectiveness, comfort, and patient-centered outcomes.

Keywords: blood flow rate, chronic kidney failure, hemodialysis, Urea Reduction Ratio, uremic pruritus.



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INTRODUCTION

Chronic kidney disease (CKD) is a structural or functional kidney disorder that progresses over time and may impair the body's ability to maintain fluid and electrolyte homeostasis as well as eliminate metabolic waste products. Progressive deterioration of kidney function to an advanced stage leads to the accumulation of uremic toxins and increases the need for kidney replacement therapy, particularly hemodialysis, to maintain physiological function and patient survival (Levin et al., 2023). The burden of hemodialysis services is also evident at Harapan Anda University Hospital in Tegal, where 376 patients were recorded in 2024, 359 patients in 2025, and 180 patients during January–March 2026. This substantial demand for hemodialysis services indicates that the quality of therapy should be evaluated not only in terms of treatment continuity but also in relation to dialysis adequacy and the control of complications experienced by patients.

Hemodialysis functions through diffusion and ultrafiltration processes to remove metabolic waste products, control excess fluid, and restore electrolyte balance in patients with severe kidney dysfunction. Although this therapy can prolong survival, patients undergoing hemodialysis remain vulnerable to various symptoms that may reduce comfort and quality of life, one of which is chronic kidney disease-associated pruritus (CKD-aP), also known as uremic pruritus. Latus et al. (2025) reported that moderate-to-severe pruritus is still experienced by approximately 31–40% of hemodialysis patients and is frequently underreported or insufficiently recognized in clinical practice. Shetty et al. (2023) also found pruritus in 55.83% of maintenance hemodialysis patients and demonstrated that greater pruritus severity was associated with poorer quality of life and sleep quality.

Uremic pruritus is a multifactorial clinical manifestation whose mechanism cannot be explained solely by structural skin abnormalities in patients with CKD. The accumulation of uremic toxins, systemic inflammation, xerosis, immune dysregulation, peripheral neural dysfunction, altered opioid

balance, and abnormalities in mineral metabolism are believed to interact in the development of pruritic sensations (Brennan, 2024; Latus et al., 2025). This condition may produce persistent or recurrent itching that subsequently results in excoriation, sleep disturbance, fatigue, mood disturbances, and reduced ability to perform daily activities (Shetty et al., 2023). The complexity of its pathogenesis indicates that the management of uremic pruritus should consider both patient-related clinical factors and factors associated with the effectiveness of hemodialysis.

One technical parameter that influences the effectiveness of hemodialysis is the blood flow rate (QB), which refers to the volume of blood circulated through the dialyzer per unit of time during dialysis. Increasing blood flow enables a greater volume of blood to come into contact with the dialyzer membrane and may therefore enhance solute transfer and removal when supported by adequate vascular access, dialyzer performance, treatment duration, and other dialysis parameters. Zhang et al. (2024) demonstrated that effective blood flow rate is an important parameter in maintenance hemodialysis and is associated with several clinical outcomes, although the magnitude of its effect may vary according to individual characteristics and dialysis prescriptions. Therefore, QB adjustment should not be regarded merely as an operational setting of the hemodialysis machine but as part of the optimization of dialysis dose and solute clearance in patients with CKD.

The effectiveness of urea removal during a single hemodialysis session can be assessed using the Urea Reduction Ratio (URR), which represents the percentage decrease in blood urea concentration after hemodialysis compared with the predialysis level. URR is a relatively simple indicator of dialysis adequacy and remains relevant for evaluating hemodialysis quality because it reflects the capacity of treatment to reduce the urea burden during a dialysis session. Chen et al. (2023) demonstrated that URR has prognostic value comparable to Kt/V for all-cause mortality in hemodialysis patients, while patients with higher URR values showed better survival outcomes than those with URR values below 65%. Consequently, a low URR may indicate suboptimal urea clearance and should prompt evaluation of several components of the dialysis prescription, including QB, dialysis duration, dialyzer characteristics, and vascular access.

The conceptual relationship among QB, URR, and uremic pruritus can be explained through the effectiveness of metabolic waste removal during hemodialysis. Suboptimal QB may limit the volume of blood processed through the dialyzer and subsequently affect dialysis adequacy, whereas a low URR indicates insufficient reduction of blood urea after hemodialysis (Chen et al., 2023; Zhang et al., 2024). Inadequate solute clearance may theoretically sustain the uremic environment associated with various clinical manifestations, including pruritus, although the pathogenesis of CKD-aP also involves complex inflammatory, neurological, dermatological, and metabolic pathways (Brennan, 2024; Latus et al., 2025). The optimization of hemodialysis parameters is therefore clinically relevant as one of the modifiable factors that may be associated with the severity of uremic pruritus.

Empirical evidence regarding the relationship between dialysis-related parameters and uremic pruritus remains inconsistent, indicating an important area for further investigation. Shetty et al. (2023), for example, did not identify significant associations between several dialysis-related factors or laboratory parameters and the occurrence of pruritus in maintenance hemodialysis patients, whereas other literature continues to emphasize dialysis optimization as an important aspect of CKD-aP management (Latus et al., 2025). In addition, studies on effective blood flow rate have primarily focused on dialysis adequacy and general clinical outcomes, while URR-related studies have mainly addressed dialysis sufficiency and prognosis, leaving relatively limited evidence regarding the simultaneous relationship of QB and URR with uremic pruritus (Chen et al., 2023; Zhang et al., 2024). This gap is particularly relevant in local hemodialysis settings because patient characteristics, dialysis prescriptions, vascular access quality, and clinical practices may differ across dialysis units.

Harapan Anda University Hospital in Tegal serves a substantial population of patients undergoing hemodialysis, making the monitoring of dialysis parameters and patient-reported symptoms essential for improving the quality of nursing and clinical services. Examining the relationship of QB and URR with uremic pruritus may provide evidence as to whether these routinely obtainable hemodialysis parameters are associated with the severity of pruritic symptoms while supporting a treatment approach that prioritizes both dialysis adequacy and patient comfort (Chen et al., 2023; Latus et al., 2025). This study also offers contextual novelty by simultaneously examining two parameters representing the dialysis process and dialysis outcome, namely QB as a technical blood flow parameter and URR as an indicator of urea reduction, in relation to the symptomatic

outcome of uremic pruritus within the same patient population. Accordingly, this study aims to analyze the relationship between blood flow rate (QB) and Urea Reduction Ratio (URR) and uremic pruritus among patients with chronic kidney failure undergoing hemodialysis at Harapan Anda University Hospital in Tegal.

RESEARCH METHODS

This study employed a quantitative approach with a descriptive-correlational design and a cross-sectional method to examine the relationship between blood flow rate (QB), Urea Reduction Ratio (URR), and uremic pruritus among patients with chronic kidney failure undergoing hemodialysis at Harapan Anda University Hospital in Tegal. The study population consisted of 180 patients receiving hemodialysis during March–April 2026, from whom 52 respondents were selected using a non-probability purposive sampling technique based on predetermined inclusion and exclusion criteria. Blood flow rate (QB) was obtained directly from the hemodialysis machine observation records, while URR was calculated from pre- and post-hemodialysis blood urea measurements. Uremic pruritus was assessed using the 5-D Itch Scale, which evaluates five dimensions of pruritus, namely degree, duration, direction, disability, and distribution.

QB was categorized as low (<200 mL/min), moderate (200–300 mL/min), or high (>300 mL/min), whereas URR was classified as adequate when the value was $\geq 65\%$ and inadequate when it was $<65\%$. Uremic pruritus severity was classified according to the 5-D Itch Scale into no pruritus, mild, moderate, severe, and very severe pruritus. Data analysis consisted of univariate and bivariate analyses; univariate analysis was used to describe respondent characteristics and the distributions of QB, URR, and uremic pruritus, while bivariate analysis was performed using Spearman's rank correlation test to assess the relationships between QB and uremic pruritus and between URR and uremic pruritus. Statistical significance was determined at a p-value <0.05 , indicating a statistically significant relationship between the variables.

RESULTS AND DISCUSSION

Blood Flow Rate (QB) and Uremic Pruritus

The findings showed that blood flow rate (QB) varied considerably among patients undergoing maintenance hemodialysis at Harapan Anda University Hospital in Tegal. Of the 52 respondents, 36 patients (69.2%) received hemodialysis with a moderate QB of 200–300 mL/min, whereas 16 patients (30.8%) were treated with a low QB of <200 mL/min; no respondents were classified in the high-QB category. This distribution indicates that moderate blood flow was the predominant prescription in the study population and may reflect adjustments made according to vascular access performance, hemodynamic tolerance, and individual clinical conditions. Blood flow is an important component of dialysis prescription because it influences the quantity of blood delivered to the dialyzer and therefore contributes to the efficiency of solute removal during each treatment session (Daugirdas et al., 2015; Fardiansyah et al., 2024).

Differences in pruritus severity were apparent between the two QB categories. Among patients receiving a low QB, 8 of 16 respondents (50.0%) experienced moderate pruritus and 6 (37.5%) experienced severe pruritus, whereas only 2 (12.5%) had mild pruritus and none were free from itching. In contrast, among patients receiving a moderate QB, only 1 of 36 respondents (2.8%) experienced severe pruritus, while 20 (55.6%) had moderate pruritus, 13 (36.1%) had mild pruritus, and 2 (5.6%) reported no pruritus. This distribution suggests a clinically meaningful shift toward less severe itching among patients receiving a more favorable blood flow rate, consistent with the principle that dialysis-related factors may contribute to the burden of CKD-associated pruritus (Abdallah et al., 2023; Agarwal et al., 2023).

The statistical analysis further supported this pattern. Spearman's rank correlation yielded a coefficient of -0.493 with a p-value $< .001$, indicating a statistically significant, moderate, and inverse relationship between QB and uremic pruritus severity. The negative coefficient means that increasing QB categories were associated with decreasing levels of pruritus severity, although the cross-sectional nature of the study does not establish that a higher QB directly causes improvement in itching. This distinction is important because CKD-associated pruritus has a complex multifactorial pathogenesis and cannot be attributed to a single dialysis parameter (Brennan, 2024; Ko et al., 2023).

From a physiological perspective, the observed association is plausible because QB determines the rate at which blood is presented to the dialyzer membrane for solute exchange. When blood flow is insufficient, the amount of blood processed during a dialysis session may be reduced, potentially limiting effective solute clearance unless compensated for by other components of the dialysis prescription. Fardiansyah et al. (2024) reported an association between blood flow rate and hemodialysis adequacy, while Zhang et al. (2024) demonstrated that effective blood flow rate is clinically relevant to outcomes among maintenance hemodialysis patients. These findings reinforce the interpretation that QB should be viewed as an integral component of dialysis delivery rather than merely as a technical machine setting.

The difference in severe-pruritus prevalence between the QB groups is particularly notable: severe itching occurred in 37.5% of patients with low QB but in only 2.8% of patients with moderate QB. Nevertheless, this pattern should be interpreted as an association rather than evidence of an isolated QB effect because the delivered dialysis dose is jointly determined by treatment time, dialyzer characteristics, vascular access, blood flow, dialysate flow, recirculation, and patient-specific factors. Iman et al. (2024) demonstrated the importance of dialysis prescription parameters in determining adequacy, whereas Jia et al. (2025) emphasized that dialysis adequacy is influenced by several potentially modifiable treatment-related factors. Consequently, QB may influence pruritus partly through its contribution to overall dialysis performance and solute clearance rather than through a direct antipruritic mechanism.

Table 1. Relationship between Blood Flow Rate (QB) and Uremic Pruritus Severity

Uremic pruritus severity	Low QB, <200 mL/min n (%)	Moderate QB, 200–300 mL/min n (%)	Total, n (%)
No pruritus	0 (0.0)	2 (5.6)	2 (3.8)
Mild	2 (12.5)	13 (36.1)	15 (28.8)
Moderate	8 (50.0)	20 (55.6)	28 (53.8)
Severe	6 (37.5)	1 (2.8)	7 (13.5)
Very severe	0 (0.0)	0 (0.0)	0 (0.0)
Total	16 (100.0)	36 (100.0)	52 (100.0)

Spearman's rank correlation: $r = -0.493$; $p < .001$.

The predominance of moderate pruritus in both QB groups also demonstrates that increasing QB alone is unlikely to eliminate CKD-associated itching. Even within the moderate-QB group, more than half of the respondents continued to experience moderate pruritus, indicating the persistence of mechanisms that are not completely corrected by conventional hemodialysis. CKD-associated pruritus has been linked to systemic inflammation, immune dysregulation, peripheral neuropathy, xerosis, opioid-system abnormalities, mineral metabolism disturbances, and retention of various uremic substances (Cheng & Wong, 2022; Ko et al., 2023; Molina et al., 2023). Therefore, the moderate correlation observed in this study is biologically consistent with a multifactorial condition in which QB represents only one component of a broader pathogenic pathway.

The present findings can also be interpreted in the context of the distinction between blood flow and actual delivered dialysis dose. A higher prescribed QB does not automatically guarantee adequate dialysis if vascular access dysfunction, recirculation, shortened dialysis duration, insufficient dialyzer performance, or other technical limitations are present. Research on dialysis dose has emphasized that assessment of treatment effectiveness should integrate measures of solute removal rather than relying on a single machine parameter (Li et al., 2025; Liu et al., 2024). Accordingly, the significant QB–pruritus relationship found in this study should ideally be considered together with URR and other measures of dialysis adequacy when determining whether insufficient toxin clearance contributes to persistent itching.

Urea kinetics provide an additional conceptual explanation for this association. Blood flow affects the delivery of circulating solutes to the dialyzer, while the efficiency of their removal depends on mass transfer across the dialysis membrane and the interaction between patient, dialyzer, and treatment characteristics. Rubin et al. (2024) demonstrated the complexity of urea kinetic behavior during hemodialysis, suggesting that changes in treatment parameters should be understood within a

dynamic physiological system rather than as isolated determinants. Although urea itself is not regarded as the sole pruritogenic toxin, insufficient clearance can serve as an indicator of the broader retention of substances associated with the uremic state and may therefore indirectly reflect conditions favorable to persistent CKD-associated pruritus (Marcello et al., 2024).

The clinical relevance of optimizing QB is further supported by evidence that blood flow rate is associated with outcomes extending beyond symptom control. Zhao et al. (2022) identified blood flow rate as an independent factor associated with mortality among Chinese hemodialysis patients, while Zhang et al. (2024) reported associations between effective blood flow and clinical outcomes in maintenance hemodialysis. These studies do not demonstrate a direct causal effect of QB on pruritus, but they emphasize that inappropriate blood flow may indicate or contribute to suboptimal dialysis delivery. In clinical practice, QB should therefore be individualized according to vascular access condition, cardiovascular tolerance, prescribed dialysis dose, and treatment objectives rather than increased indiscriminately solely to reduce itching.

From a nursing perspective, the results underscore the importance of integrating machine-based parameters with systematic symptom assessment during hemodialysis care. Nurses are strategically positioned to monitor the prescribed and achieved QB, detect access-related problems or intradialytic intolerance, evaluate changes in pruritus severity, and communicate potential inadequacy to the multidisciplinary dialysis team. Regular evaluation of pruritus using a standardized instrument such as the 5-D Itch Scale can complement objective dialysis parameters and support more patient-centered treatment decisions, particularly because itching is frequently underrecognized in routine dialysis care (Lai et al., 2017; Engler et al., 2024). Such monitoring is consistent with contemporary CKD care, which increasingly emphasizes both treatment adequacy and symptom burden as meaningful dimensions of quality care (KDIGO CKD Work Group, 2024).

This study demonstrates a significant inverse relationship between blood flow rate and uremic pruritus severity, with patients in the low-QB group displaying a markedly greater proportion of severe itching than those receiving moderate QB. The moderate magnitude of the correlation ($r = -0.493$) suggests that QB has a meaningful association with pruritus but does not independently account for the entire clinical presentation. The finding supports optimization of dialysis delivery while simultaneously recognizing that CKD-associated pruritus requires assessment of additional factors such as dialysis adequacy, uremic toxin burden, inflammation, mineral abnormalities, xerosis, comorbidities, and individual symptom susceptibility (Brennan, 2024; Latus et al., 2025). Thus, QB should be interpreted as one modifiable dialysis-related factor within a comprehensive strategy for improving treatment effectiveness and reducing symptom burden among patients receiving maintenance hemodialysis.

Urea Reduction Ratio (URR) and Uremic Pruritus

The findings demonstrated a clear difference in the distribution of uremic pruritus severity according to Urea Reduction Ratio (URR) adequacy. Of the 52 patients undergoing hemodialysis, 36 respondents (69.2%) achieved an adequate URR, whereas 16 respondents (30.8%) had an inadequate URR. This distribution indicates that most patients achieved the expected level of urea removal during a single hemodialysis session, although almost one-third remained below the adequacy threshold. URR remains an important and practical indicator of dialysis performance because it directly represents the proportional reduction in blood urea concentration between the pre- and post-dialysis measurements (Chen et al., 2023; Li et al., 2025).

A pronounced difference in pruritus severity was observed between patients with adequate and inadequate URR. Among the 16 patients with inadequate URR, 7 respondents (43.8%) experienced severe pruritus, 8 (50.0%) experienced moderate pruritus, and only 1 (6.2%) experienced mild pruritus, while none were free from itching. By comparison, no severe pruritus was observed among the 36 patients with adequate URR; instead, 20 patients (55.6%) experienced moderate pruritus, 14 (38.9%) experienced mild pruritus, and 2 (5.6%) reported no pruritus. The concentration of severe itching exclusively within the inadequate-URR group suggests that insufficient dialysis adequacy may be clinically associated with a greater symptom burden in patients receiving maintenance hemodialysis (Rahayu et al., 2025; Agarwal et al., 2023).

Spearman's rank correlation confirmed a statistically significant inverse relationship between URR and uremic pruritus, with a correlation coefficient of -0.517 and a p -value $< .001$. The

magnitude of the coefficient represents a moderate relationship, while its negative direction indicates that greater dialysis adequacy, as reflected by URR, was associated with lower pruritus severity. This result is clinically important because URR is not merely a biochemical measurement but an indicator of the effectiveness with which a dialysis session reduces circulating urea. Chen et al. (2023) similarly demonstrated the clinical relevance of URR by showing that it has prognostic value comparable to Kt/V for all-cause mortality in maintenance hemodialysis patients.

The biological plausibility of this relationship can be understood through the role of dialysis in removing accumulated metabolic solutes. Inadequate dialysis allows greater retention of uremic substances, some of which may contribute directly or indirectly to inflammatory, neurological, and metabolic pathways implicated in CKD-associated pruritus. Although urea itself is not considered the sole pruritogenic toxin, an inadequate URR may function as a surrogate marker of insufficient overall solute removal and a persistent uremic milieu (Molina et al., 2023; Marcello et al., 2024). Consequently, patients with lower URR values may remain exposed to metabolic conditions that facilitate persistent or more severe itching despite receiving regular hemodialysis.

The relationship between URR and pruritus should also be interpreted within the broader framework of dialysis dose. URR and Kt/V are both measures of dialysis adequacy, although they differ in calculation and the extent to which they incorporate patient and treatment characteristics. Jeon et al. (2024) demonstrated that Kt/Vurea is associated with clinical outcomes among maintenance hemodialysis patients, while Li et al. (2025) emphasized the importance of accurate assessment and interpretation of dialysis adequacy indices. These findings reinforce the clinical implication that inadequate removal of urea or other retained solutes may signify a broader need to evaluate and optimize the delivered dialysis dose.

Table 2. Relationship between Urea Reduction Ratio (URR) and Uremic Pruritus Severity

Uremic pruritus severity	Inadequate URR n (%)	Adequate URR n (%)	Total n (%)
No pruritus	0 (0.0)	2 (5.6)	2 (3.8)
Mild	1 (6.2)	14 (38.9)	15 (28.8)
Moderate	8 (50.0)	20 (55.6)	28 (53.8)
Severe	7 (43.8)	0 (0.0)	7 (13.5)
Very severe	0 (0.0)	0 (0.0)	0 (0.0)
Total	16 (100.0)	36 (100.0)	52 (100.0)

Spearman's rank correlation: $r = -0.517$; $p < .001$. Adequate URR was defined as $\geq 65\%$, whereas inadequate URR was defined as $< 65\%$.

The absence of severe pruritus among patients with adequate URR is one of the most clinically relevant findings of this study. Rahayu et al. (2025) also reported an association between adequate URR and the degree of uremic pruritus among patients with chronic kidney disease undergoing hemodialysis, supporting the present observation that better urea reduction may correspond to less severe itching. Nevertheless, more than half of the adequate-URR group continued to experience moderate pruritus, indicating that adequate removal of urea alone does not completely prevent CKD-associated pruritus. This residual symptom burden is consistent with the multifactorial nature of the disorder, which involves immune activation, systemic inflammation, xerosis, mineral disturbances, neural sensitization, and alterations in opioid signaling in addition to uremic toxin accumulation (Brennan, 2024; Cîrstea et al., 2025).

The achievement of an adequate URR depends on several modifiable and non-modifiable components of hemodialysis delivery. Treatment duration, blood flow rate, dialysate flow rate, dialyzer characteristics, effective vascular access, recirculation, treatment interruptions, patient body size, and residual kidney function can all affect the final dialysis dose. Jia et al. (2025) identified multiple determinants of dialysis adequacy in maintenance hemodialysis patients, while Iman et al. (2024) demonstrated that dialysis flow-related parameters remain relevant when evaluating treatment adequacy. Therefore, an inadequate URR should prompt clinical evaluation of the entire dialysis prescription rather than simply being interpreted as an isolated laboratory abnormality.

The present findings also support the importance of integrating URR assessment with other dialysis-related parameters, particularly QB. Blood delivered to the dialyzer must be sufficient to

facilitate effective solute exchange, but blood flow alone does not determine dialysis adequacy because membrane performance, dialysate flow, treatment duration, and vascular access also contribute to the delivered dose. Rydzewska-Rosołowska et al. (2024) showed that alterations in dialysate flow can be evaluated without compromising adequacy when dialysis prescriptions are appropriately managed, illustrating that adequacy reflects the interaction of several treatment components. Similarly, Rubin et al. (2024) demonstrated through urea kinetic modeling that solute behavior during hemodialysis is dynamic, supporting interpretation of URR as the product of multiple physiological and technical processes rather than a single machine setting.

The moderate strength of the URR–pruritus association further indicates that dialysis adequacy explains only part of the variability in itching severity. Some patients with adequate URR continued to experience moderate symptoms, suggesting the influence of factors beyond urea clearance, including xerosis, calcium-phosphate imbalance, parathyroid hormone abnormalities, systemic inflammation, anemia, nutritional status, neuropathic changes, comorbid disease, and individual susceptibility to pruritic signaling (Ko et al., 2023; Buades et al., 2024). This interpretation is supported by contemporary CKD-aP literature showing considerable heterogeneity in clinical presentation even among patients receiving apparently adequate maintenance dialysis (Engler et al., 2024; Latus et al., 2025). Hence, URR should be considered an important but incomplete marker when investigating the mechanisms underlying uremic pruritus.

The findings have direct implications for clinical and nursing practice because URR can be routinely calculated from pre- and post-dialysis blood urea measurements and therefore provides an accessible means of monitoring delivered treatment adequacy. Patients with persistently inadequate URR, particularly those who simultaneously report moderate or severe pruritus, may require evaluation of dialysis duration, QB, vascular access function, treatment adherence, dialyzer performance, and other potentially correctable factors. Evidence that interventions capable of improving dialysis adequacy can also contribute to broader patient outcomes further strengthens the rationale for continuous treatment optimization (Rohmah et al., 2024; Liu et al., 2024). Nurses therefore have an important role in monitoring dialysis completion, identifying interruptions and access problems, documenting symptoms, and coordinating further assessment when the delivered dialysis dose appears insufficient.

The present study demonstrates that URR is significantly and inversely associated with uremic pruritus severity among patients undergoing hemodialysis at Harapan Anda University Hospital in Tegal. Patients with inadequate URR showed a markedly greater burden of severe itching, whereas no severe pruritus was observed among those who achieved adequate URR, producing a moderate negative correlation of $r = -0.517$. The findings support the hypothesis that more effective dialysis and improved removal of retained solutes may contribute to reducing the severity of CKD-associated pruritus, while simultaneously confirming that adequate URR does not completely eliminate this multifactorial symptom (Marcello et al., 2024; Latus et al., 2025). Routine assessment of URR should therefore be combined with systematic pruritus evaluation and broader clinical assessment to support individualized dialysis optimization and symptom-oriented care.

Uremic Pruritus, Urea Removal, and Clinical Implications

Uremic pruritus remained a substantial symptom burden among the patients undergoing hemodialysis in this study. Of the 52 respondents, 28 patients (53.8%) experienced moderate pruritus, 15 (28.8%) experienced mild pruritus, 7 (13.5%) experienced severe pruritus, and only 2 (3.8%) reported no pruritus, while no patient was classified as having very severe pruritus. Thus, 96.2% of the study population experienced some degree of itching, demonstrating that regular hemodialysis does not necessarily eliminate CKD-associated pruritus. This finding is consistent with international evidence showing that pruritus remains common among maintenance hemodialysis populations and continues to represent an underrecognized component of symptom burden (Pisoni et al., 2006; Shetty et al., 2023; Engler et al., 2024).

The predominance of moderate pruritus observed in the present study is clinically relevant because even symptoms below the severe category may have important consequences for patient well-being. CKD-associated pruritus has been associated with impaired sleep, fatigue, psychological distress, reduced daily functioning, and deterioration in health-related quality of life (Agarwal et al., 2023; Thompson et al., 2024). A systematic review by Wang et al. (2025) further demonstrated that

CKD-associated pruritus is consistently associated with adverse patient-centered outcomes, confirming that itching should not be regarded as a minor dermatological complaint. Accordingly, the high proportion of respondents experiencing moderate or severe symptoms in this study supports routine assessment of pruritus as part of comprehensive hemodialysis care.

Several pathophysiological mechanisms may explain the persistence of pruritus despite regular renal replacement therapy. Proposed mechanisms include accumulation of uremic toxins, systemic inflammation, dysregulated immune responses, xerosis, disturbances in calcium-phosphate and parathyroid hormone metabolism, peripheral neuropathy, and altered endogenous opioid signaling (Mettang & Kremer, 2015; Brennan, 2024; Skrzypczak et al., 2024). Molina et al. (2023) emphasized that CKD-associated pruritus emerges from the interaction of multiple biological pathways rather than from a single causative factor. This multifactorial pathogenesis explains why improving dialysis adequacy may reduce symptom severity without completely eliminating itching in every patient.

The laboratory findings provide additional evidence concerning the effectiveness of urea removal during hemodialysis. The mean predialysis urea concentration was 140.98 mg/dL, with values ranging from 99 to 223 mg/dL, whereas the mean post-dialysis concentration decreased to 45.67 mg/dL, with values ranging from 20 to 111 mg/dL. The substantial reduction between pre- and post-dialysis measurements indicates that hemodialysis effectively removed a considerable proportion of circulating urea, although interindividual variability remained evident. Urea kinetic behavior during hemodialysis is influenced by multiple physiological and technical factors, and therefore individual post-dialysis values may vary even under apparently similar treatment conditions (Rubin et al., 2024; Li et al., 2025).

Table 3. Distribution of Uremic Pruritus Severity among Hemodialysis Patients

Uremic pruritus severity	Frequency (n)	Percentage (%)
No pruritus	2	3.8
Mild	15	28.8
Moderate	28	53.8
Severe	7	13.5
Very severe	0	0.0
Total	52	100.0

The distribution presented in Table 3 demonstrates that moderate pruritus constituted the dominant category, while approximately one in seven respondents experienced severe itching. Contemporary epidemiological studies similarly report substantial heterogeneity in CKD-aP intensity among patients receiving maintenance hemodialysis, with symptom severity differing according to clinical characteristics, dialysis factors, comorbidities, and individual susceptibility (Li et al., 2025; Wang et al., 2025). Krismi et al. (2023) additionally highlighted the contribution of xerosis to CKD-associated pruritus among hemodialysis patients, suggesting that cutaneous factors may remain clinically relevant even when dialysis-related parameters are adequately controlled. Therefore, the symptom distribution identified in the present study should be interpreted within a multidimensional framework rather than solely through biochemical clearance.

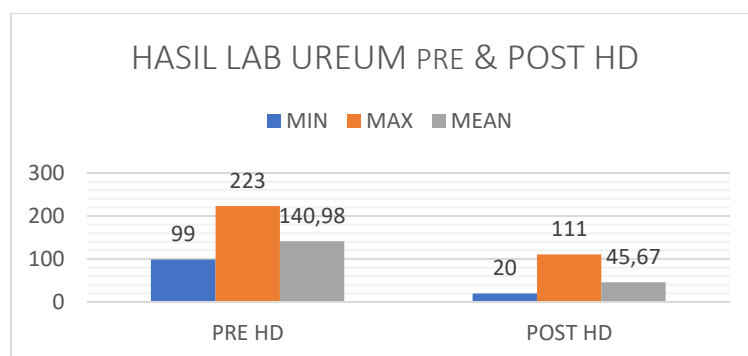


Figure 1. Pre- and Post-Hemodialysis Urea Laboratory Results

As illustrated in Figure 1, a substantial reduction in blood urea levels was observed following the hemodialysis session, with the mean concentration decreasing from 140.98 mg/dL before dialysis to 45.67 mg/dL after dialysis. This marked decline demonstrates the effectiveness of hemodialysis in removing circulating urea; however, considerable interindividual variability remained, as post-dialysis values ranged from 20 to 111 mg/dL. The persistence of moderate and severe pruritus despite substantial urea reduction indicates that urea removal alone cannot fully explain CKD-associated pruritus, because other retained uremic solutes and inflammatory, neurological, dermatological, and metabolic mechanisms may also contribute to symptom development (Marcello et al., 2024; Molina et al., 2023). Therefore, the laboratory findings should be interpreted together with URR, QB, and clinical assessment of pruritus severity rather than as an isolated indicator of symptom control.

The original figure illustrates the marked decrease in circulating urea following hemodialysis and visually complements the URR findings reported in the preceding subsection. Nevertheless, the persistence of moderate and severe pruritus despite substantial urea reduction confirms that urea concentration alone cannot explain the entire symptom complex. Blood purification therapies remove different molecular classes with varying efficiency, and conventional urea-based adequacy measures may not fully represent the clearance of all compounds implicated in CKD-associated pruritus (Marcello et al., 2024). This interpretation supports combining laboratory markers of dialysis adequacy with direct assessment of patient symptoms when evaluating the effectiveness of hemodialysis.

The findings are also consistent with evidence that CKD-associated pruritus may persist even when conventional dialysis targets are achieved, which has led to the development of symptom-specific pharmacological interventions. Randomized clinical evidence has demonstrated the efficacy of the peripheral κ -opioid receptor agonist difelikefalin for moderate-to-severe CKD-associated pruritus in patients receiving hemodialysis (Narita et al., 2022; Topf et al., 2022). Rastogi et al. (2023) similarly highlighted difelikefalin as a targeted therapeutic option when optimization of dialysis and correction of contributing metabolic abnormalities are insufficient to control symptoms. More recent real-world evidence indicates that targeted antipruritic therapy is increasingly being integrated into hemodialysis care for patients with persistent clinically significant symptoms (Ficociello et al., 2025).

The therapeutic literature further reinforces the need to distinguish between correcting dialysis-related contributors and directly treating pruritus pathways. Pan et al. (2025) reported favorable efficacy and safety findings for HSK21542, another κ -opioid receptor-targeted therapy, illustrating the growing recognition of neural and opioid mechanisms in CKD-associated pruritus. Consensus recommendations consequently advocate a stepwise approach that includes optimization of dialysis adequacy, correction of metabolic abnormalities, treatment of xerosis, and the use of evidence-based antipruritic therapies according to symptom severity (Buades et al., 2024; Latus et al., 2025). The present findings support this multidimensional strategy because substantial differences in pruritus severity were associated with QB and URR, yet clinically relevant itching remained present even among patients with more favorable dialysis parameters.

Nursing management is particularly important because pruritus is subjective and may remain undetected unless patients are specifically questioned using a structured assessment. The 5-D Itch Scale used in this study incorporates degree, duration, direction, disability, and distribution, allowing the burden of itching to be evaluated more comprehensively than a single intensity question (Lai et al., 2017). Routine symptom assessment should be integrated with monitoring of QB, URR, vascular access function, dialysis completion, laboratory abnormalities, skin condition, sleep disturbance, and quality-of-life consequences. This approach is consistent with contemporary recommendations emphasizing that CKD care should address symptoms and patient-centered outcomes in addition to conventional biochemical and dialysis adequacy targets (KDIGO CKD Work Group, 2024; Venugopal et al., 2025).

The high prevalence of pruritus observed in this study also has implications for treatment adherence and overall disease burden. Persistent itching may contribute to sleep disruption, fatigue, emotional distress, and reduced willingness to tolerate the repetitive demands of long-term dialysis, thereby amplifying the already considerable burden experienced by patients with advanced kidney disease (Patimah et al., 2024; Thompson et al., 2024). Interventions directed solely at dialysis machine parameters may therefore be insufficient when patients also have xerosis, inflammatory

abnormalities, metabolic disturbances, neuropathic mechanisms, or significant psychosocial consequences. Supportive skin care interventions may offer additional benefit in selected patients, as illustrated by Astriya et al. (2024), while specialist assessment is warranted when symptoms remain moderate to severe despite optimization of dialysis and basic supportive measures.

The three dimensions analyzed in this study form a clinically coherent pattern: QB represents an important technical component of dialysis delivery, URR reflects the effectiveness of urea removal, and uremic pruritus represents a patient-centered symptomatic outcome. The significant inverse correlations found between QB and pruritus ($r = -0.493$) and between URR and pruritus ($r = -0.517$) suggest that better dialysis-related parameters are associated with lower symptom severity, although neither relationship is sufficiently strong to support a single-factor explanation. Evidence from contemporary CKD-aP research similarly indicates that effective blood purification should be combined with dermatological, metabolic, neurological, pharmacological, and patient-centered approaches to achieve optimal symptom control (Skrzypczak et al., 2024; Cîrstea et al., 2025; Wang et al., 2025). These findings therefore support an integrated clinical strategy in which dialysis adequacy and blood flow are routinely optimized while pruritus is independently assessed and managed as an important outcome among patients receiving long-term hemodialysis.

CONCLUSION

The study demonstrated that blood flow rate (QB) and Urea Reduction Ratio (URR) were significantly associated with the severity of uremic pruritus among patients with chronic kidney failure undergoing hemodialysis at Harapan Anda University Hospital in Tegal. The relationship between QB and uremic pruritus was negative and moderate ($r = -0.493$; $p < .001$), indicating that patients receiving more optimal blood flow tended to experience lower levels of pruritus. Similarly, URR showed a significant moderate negative correlation with uremic pruritus ($r = -0.517$; $p < .001$), suggesting that greater dialysis adequacy was associated with reduced pruritus severity. These findings reinforce the importance of effective dialysis delivery in controlling symptom burden among patients receiving maintenance hemodialysis.

The results also indicate that QB and URR are not the only determinants of uremic pruritus because clinically relevant itching remained present even among patients with more favorable dialysis parameters. Management of CKD-associated pruritus should therefore integrate optimization of blood flow and dialysis adequacy with systematic assessment of skin condition, metabolic abnormalities, inflammation, comorbidities, and other contributing factors. Routine monitoring of QB, URR, and pruritus severity can assist nurses and other hemodialysis professionals in identifying patients requiring further evaluation and treatment adjustment. An integrated approach combining dialysis optimization with symptom-oriented care is expected to improve patient comfort, treatment effectiveness, and quality of life.

REFERENCES

- Abdallah, A. M., Elsheikh, S. M., & ElBarbary, R. A. (2023). Prevalence and determinants of severity of uremic pruritus in hemodialysis patients: A multicentric study. *Journal of Investigative Medicine*, 71(1), 42–46. <https://doi.org/10.1136/jim-2022-002360>
- Agarwal, R., Burton, J., Gallieni, M., Kalantar-Zadeh, K., Mayer, G., Pollock, C., & Szepietowski, J. C. (2023). Alleviating symptoms in patients undergoing long-term hemodialysis: A focus on chronic kidney disease-associated pruritus. *Clinical Kidney Journal*, 16(1), 30–40. <https://doi.org/10.1093/ckj/sfac187>
- Astriya, O., Fatmawati, Z. I., & Sucipto, A. (2024). Pengaruh stroking massage dan olive oil terhadap penurunan skala pruritus uremik pada pasien gagal ginjal kronis yang menjalani hemodialisa di RSUD Sultan Imanudin Pangkalan Bun. *Jurnal Borneo Cendekia*, 8(1), 113–121. <https://doi.org/10.54411/jbc.v8i1.535>
- Brennan, F. (2024). The pathogenesis of CKD-associated pruritus: A theoretical model and relevance for treatment. *Kidney360*, 5(11), 1727–1738. <https://doi.org/10.34067/KID.0000000573>
- Buades, J. M., Figueras-Nart, I., Goicoechea, M., Sánchez-Villanueva, R. J., & Serra-Baldrich, E. (2024). Information and consensus document for the diagnostic and therapeutic management of pruritus associated with chronic kidney disease in patients on haemodialysis in Spain. *Nefrología (English Edition)*, 44(4), 465–474. <https://doi.org/10.1016/j.nefro.2024.07.003>

- Chen, Y.-K., Chu, C.-S., Niu, S.-W., Lin, H. Y.-H., Yu, P.-H., Shen, F.-C., Chao, Y.-L., Kuo, I.-C., Hung, C.-C., & Chang, J.-M. (2023). The prognostic value of URR equals that of Kt/V for all-cause mortality in Taiwan after 10-year follow-up. *Scientific Reports*, 13(1), 8923. <https://doi.org/10.1038/s41598-023-35353-8>
- Cheng, A.-Y., & Wong, L.-S. (2022). Uremic pruritus: From diagnosis to treatment. *Diagnostics*, 12(5), 1108. <https://doi.org/10.3390/diagnostics12051108>
- Cîrstea, Ș., Orzan, O. A., & Zilișteanu, D. S. (2025). Pruritus in uremic patients: Approaches to alleviating a common symptom in chronic kidney disease. *Life*, 15(7), 1001. <https://doi.org/10.3390/life15071001>
- Daugirdas, J. T., Blake, P. G., & Ing, T. S. (Eds.). (2015). *Handbook of dialysis* (5th ed.). Wolters Kluwer Health.
- Engler, F., Kerschbaum, J., Keller, F., & Mayer, G. (2024). Prevalence, patient burden and physicians' perception of pruritus in haemodialysis patients. *Nephrology Dialysis Transplantation*, 39(2), 277–285. <https://doi.org/10.1093/ndt/gfad152>
- Fardiansyah, M. A., Harun, O., Aribowo, P., & Rahmadani, S. (2024). Hubungan kecepatan aliran darah (QB) dengan adekuasi pada pasien yang menjalani terapi hemodialisa. *Jurnal Ilmiah Keperawatan (Scientific Journal of Nursing)*, 10(1), 141–147. <https://doi.org/10.33023/jikep.v10i1.1950>
- Ficociello, L. H., Lasky, R., Arens, H.-J., Ruessmann, D., & Anger, M. S. (2025). Real-world use of difelikefalin in hemodialysis patients at a large dialysis organization in the United States: A retrospective database study. *BMC Nephrology*, 26(1), 156. <https://doi.org/10.1186/s12882-025-04074-7>
- Iman, Y., Bamforth, R., Ewhrudjakpor, R., Komenda, P., Gorbe, K., Whitlock, R., Bohm, C., Tangri, N., & Collister, D. (2024). The impact of dialysate flow rate on haemodialysis adequacy: A systematic review and meta-analysis. *Clinical Kidney Journal*, 17(7), sfac163. <https://doi.org/10.1093/ckj/sfae163>
- Jeon, J., Kim, G. O., Kim, B. Y., Son, E. J., Do, J. Y., Lee, J. E., & Kang, S. H. (2024). Effects of Kt/Vurea on outcomes according to age in patients on maintenance hemodialysis. *Clinical Kidney Journal*, 17(5), sfac116. <https://doi.org/10.1093/ckj/sfae116>
- Jia, W., He, W., Chen, Z., Wang, H., & Lu, H. (2025). Determinants of dialysis adequacy in maintenance hemodialysis patients: A cross-sectional study on modifiable risk factors and clinical interventions. *BMC Nephrology*, 26(1), 369. <https://doi.org/10.1186/s12882-025-04278-x>
- Kementerian Kesehatan Republik Indonesia. (2023). *Pedoman nasional pelayanan kedokteran tata laksana penyakit ginjal kronik*. Kementerian Kesehatan Republik Indonesia.
- Kidney Disease: Improving Global Outcomes (KDIGO) CKD Work Group. (2024). KDIGO 2024 clinical practice guideline for the evaluation and management of chronic kidney disease. *Kidney International*, 105(4S), S117–S314. <https://doi.org/10.1016/j.kint.2023.10.018>
- Ko, M.-J., Peng, Y.-S., & Wu, H.-Y. (2023). Uremic pruritus: Pathophysiology, clinical presentation, and treatments. *Kidney Research and Clinical Practice*, 42(1), 39–52. <https://doi.org/10.23876/j.krcp.21.189>
- Krismi, A., Danarti, R., Setiabudi, I. I. D. P. P., & Wirohadidjojo, Y. W. (2023). Chronic kidney disease-associated pruritus in patients undergoing hemodialysis: Xerosis and topical therapy. *Hemodialysis International*, 27(2), 91–104. <https://doi.org/10.1111/hdi.13071>
- Lai, J.-W., Chen, H.-C., Chou, C.-Y., Yen, H.-R., Li, T.-C., Sun, M.-F., Chang, H.-H., Huang, C.-C., Tsai, F.-J., Tschen, J., & Chang, C.-T. (2017). Transformation of 5-D itch scale and numerical rating scale in chronic hemodialysis patients. *BMC Nephrology*, 18, 56. <https://doi.org/10.1186/s12882-017-0475-z>
- Latus, J., Lanot, A., Ständer, S., Sanchez-Alvarez, E., Aucella, F., & Yosipovitch, G. (2025). CKD-associated pruritus in haemodialysis: A road map for diagnosis and treatment. *Clinical Kidney Journal*, 18(5), sfaf096. <https://doi.org/10.1093/ckj/sfaf096>
- Levin, A., Okpechi, I. G., Caskey, F. J., Yang, C.-W., Tonelli, M., & Jha, V. (2023). Perspectives on early detection of chronic kidney disease: The facts, the questions, and a proposed framework for 2023 and beyond. *Kidney International*, 103(6), 1004–1008. <https://doi.org/10.1016/j.kint.2023.03.009>

- Li, L.-L., Xu, R.-F., He, N., Hu, T.-L., Gao, W.-N., Wang, X.-F., Shi, D.-Y., Zhao, J.-R., & Meng, Y. (2025). Research progress on measurement methods and evaluation of the hemodialysis adequacy index Kt/V. *Therapeutic Apheresis and Dialysis*, 29(1), 3–11. <https://doi.org/10.1111/1744-9987.14217>
- Li, M., Jiang, P., Zhao, X., Ning, Y., & Huang, L. (2025). Prevalence and influencing factors of pruritus in maintenance hemodialysis patients in China: A meta-analysis. *BMC Nephrology*, 26(1), 266. <https://doi.org/10.1186/s12882-025-04163-7>
- Liu, W., Qiao, Z., Xu, Y., Zhang, Q., Xie, M., & Ma, C. (2024). Adjusting dialysis dose (Kt) scaled to body surface area (BSA) could be a more logical approach. *PLOS ONE*, 19(10), e0311175. <https://doi.org/10.1371/journal.pone.0311175>
- Marcello, M., Marturano, D., Ronco, C., & Zanella, M. (2024). The role of blood purification therapies in the treatment of chronic kidney disease-associated pruritus: A systematic review. *Clinical Kidney Journal*, 17(9), sfac266. <https://doi.org/10.1093/ckj/sfac266>
- Mettang, T., & Kremer, A. E. (2015). Uremic pruritus. *Kidney International*, 87(4), 685–691. <https://doi.org/10.1038/ki.2013.454>
- Molina, P., Ojeda, R., Blanco, A., Alcalde, G., Prieto-Velasco, M., Aresté, N., Buades, J. M., Esteve Simó, V., Goicoechea, M., Pérez-Morales, R. E., Sánchez-Álvarez, E., Sánchez-Villanueva, R., Montesa, M., & Arenas, M. D. (2023). Etiopathogenesis of chronic kidney disease-associated pruritus: Putting the pieces of the puzzle together. *Nefrología (English Edition)*, 43(1), 48–62. <https://doi.org/10.1016/j.nefro.2023.03.015>
- Narita, I., Tsubakihara, Y., Uchiyama, T., Okamura, S., Oya, N., Takahashi, N., & Gejyo, F. (2022). Efficacy and safety of difelikefalin in Japanese patients with moderate to severe pruritus receiving hemodialysis: A randomized clinical trial. *JAMA Network Open*, 5(5), e2210339. <https://doi.org/10.1001/jamanetworkopen.2022.10339>
- Nursalam. (2020). *Metodologi penelitian ilmu keperawatan: Pendekatan praktis*. Salemba Medika.
- Pan, M.-M., Gao, M., Zhou, L., Xu, Y., Yao, L., Wu, C.-Q., Mei, C.-L., Zhao, Z.-Z., Sun, D., Guan, T.-J., Chen, Q.-K., Shi, M., Xu, H., Li, Y.-M., Zhao, W.-Y., Yan, R., & Liu, B.-C. (2025). Efficacy and safety of HSK21542 for pruritus management in hemodialysis patients: A multicenter, randomized, double-blind, placebo-controlled trial. *Frontiers in Pharmacology*, 16, 1583515. <https://doi.org/10.3389/fphar.2025.1583515>
- Patimah, S., Kusumajaya, H., & Faizal, K. M. (2024). Faktor-faktor yang berhubungan dengan fatigue pada pasien gagal ginjal kronis yang menjalani hemodialisis di Rumah Sakit Umum Daerah Depati Bahrin Sungailiat tahun 2024. *Jurnal Kesehatan Tambusai*, 5(4), 11003–11012. <https://doi.org/10.31004/jkt.v5i4.31920>
- Pisoni, R. L., Wikström, B., Elder, S. J., Akizawa, T., Asano, Y., Keen, M. L., Saran, R., Mendelssohn, D. C., Young, E. W., & Port, F. K. (2006). Pruritus in haemodialysis patients: International results from the Dialysis Outcomes and Practice Patterns Study (DOPPS). *Nephrology Dialysis Transplantation*, 21(12), 3495–3505. <https://doi.org/10.1093/ndt/gfl461>
- Rahayu, S., Ningtyas, N. W. R., & Syahleman, R. (2025). Correlation of adequate urea reduction rate (URR) with the degree of uremic pruritus and sleep quality in chronic kidney disease patients undergoing hemodialysis. *Indonesian Journal of Global Health Research*, 7(4), 1153–1164. <https://doi.org/10.37287/ijghr.v7i4.7045>
- Rastogi, A., Fishbane, S., & Lerma, E. (2023). Difelikefalin for the treatment of moderate-to-severe pruritus associated with chronic kidney disease on hemodialysis. *Expert Review of Clinical Pharmacology*, 16(5), 387–400. <https://doi.org/10.1080/17512433.2023.2197209>
- Rohmah, S. N., Puspitasari, M., Prasanto, H., Wardhani, Y., Kuswadi, I., & Dhamarjati, A. (2024). Effect of intradialytic aerobic exercise intervention on dialysis adequacy and quality of life in patients with end-stage kidney disease undergoing hemodialysis at Dr. Sardjito General Hospital, Indonesia. *International Urology and Nephrology*, 56(11), 3595–3604. <https://doi.org/10.1007/s11255-024-04100-x>
- Rubin, D. M., Letts, R. F. R., Richards, X. L., Achari, S., & Pantanowitz, A. (2024). Rapid prototyping of multi-compartment models for urea kinetics in hemodialysis: A system dynamics approach. *Journal of Artificial Organs*, 27(3), 316–320. <https://doi.org/10.1007/s10047-023-01416-w>

- Rydzewska-Rosołowska, A., Głowińska, I., Kakareko, K., Pietruczuk, A., & Hryszko, T. (2024). How low can we go with the dialysate flow? A retrospective study on the safety and adequacy of a water-saving dialysis prescription. *Clinical Kidney Journal*, 17(8), sfae238. <https://doi.org/10.1093/ckj/sfae238>
- Shetty, D., Nayak, A. M., Datta, D., Bhojaraja, M. V., Nagaraju, S. P., Prabhu, A. R., Rangaswamy, D., Rao, I. R., Shenoy, S. V., & Joshi, D. (2023). Uremic pruritus: Prevalence, determinants, and its impact on health-related quality of life and sleep in Indian patients undergoing hemodialysis. *Irish Journal of Medical Science*, 192(6), 3109–3115. <https://doi.org/10.1007/s11845-023-03393-8>
- Skrzypczak, T., Skrzypczak, A., Nockowski, P., & Szepietowski, J. C. (2024). Identification and management of CKD-associated pruritus: Current insights. *International Journal of Nephrology and Renovascular Disease*, 17, 339–354. <https://doi.org/10.2147/IJNRD.S499798>
- Thompson, J., Kammerer, J., Boshears, T., Oliveira, J., Johansen, K. L., Kovar, A., Lee, L., & Yosipovitch, G. (2024). Chronic kidney disease-associated pruritus burden: A patient survey study. *Kidney Medicine*, 6(11), 100900. <https://doi.org/10.1016/j.xkme.2024.100900>
- Topf, J., Wooldridge, T., McCafferty, K., Schömig, M., Csiky, B., Zwiech, R., Wen, W., Bhaduri, S., Munera, C., Lin, R., Jebara, A., Cirulli, J., & Menzaghi, F. (2022). Efficacy of difelikefalin for the treatment of moderate to severe pruritus in hemodialysis patients: Pooled analysis of KALM-1 and KALM-2 phase 3 studies. *Kidney Medicine*, 4(8), 100512. <https://doi.org/10.1016/j.xkme.2022.100512>
- Venugopal, S., O'Hara, D. V., Agarwal, N., Hole, B. D., Snead, C. M., Stallworthy, E., Caskey, F. J., Ducharlet, K., & Smyth, B. (2025). Variation in management of CKD-associated pruritus: Results from a multinational survey of kidney units. *Kidney Medicine*, 7(7), 101028. <https://doi.org/10.1016/j.xkme.2025.101028>
- Wang, T., Goh, J. X., Seth, S., Do, L. L., Tesfaye, W., Sud, K., Van, C., Small, F., Tarafdar, S., & Castelino, R. L. (2025). Chronic kidney disease-associated pruritus and patient-centred outcomes: A systematic review. *Journal of Nephrology*, 38(2), 371–391. <https://doi.org/10.1007/s40620-025-02221-9>
- Wang, T., Goh, J.-X., Tesfaye, W., Sud, K., Van, C., Do, L. L., Tarafdar, S., & Castelino, R. L. (2025). Chronic kidney disease-associated pruritus in patients undergoing haemodialysis—A cross-sectional study. *Medicina*, 61(6), 993. <https://doi.org/10.3390/medicina61060993>
- Zhang, Z., Li, J., Ding, J., Zhang, S., Wang, M., & Xu, J. (2024). Relationship between effective blood flow rate and clinical outcomes in maintenance hemodialysis patients: A single-center study. *Renal Failure*, 46(1), 2344655. <https://doi.org/10.1080/0886022X.2024.2344655>
- Zhao, X., Niu, Q., Gan, L., Hou, F. F., Liang, X., Ni, Z., Chen, X., McCullough, K., Zhao, J., Robinson, B., Chen, Y., & Zuo, L. (2022). Blood flow rate: An independent risk factor of mortality in Chinese hemodialysis patients. *Seminars in Dialysis*, 35(3), 251–257. <https://doi.org/10.1111/sdi.13023>