



Literature Review: How do Omega-3 Fatty Acids Impact Uremic Pruritus in Hemodialysis Patients?

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Abstract

Chronic Kidney Disease-associated Pruritus (CKD-aP) is a debilitating yet often overlooked symptom. Epidemiological studies have shown that up to 40% of patients with chronic kidney disease experience moderate-to-severe pruritus. This condition is also common among patients undergoing hemodialysis. Multiple etiological factors contribute to CKD-aP, including hormonal alterations, neuropathy, increased μ - and κ -opioid receptor activity, and chronic systemic inflammation. Patients with chronic kidney disease are known to experience essential fatty acid deficiency and may therefore benefit from omega-3 fatty acid supplementation, which may help reduce inflammation and improve fatty acid balance. This review was conducted by examining prospective clinical trials investigating the effects of omega-3 fatty acids on CKD-aP that were published in English. A literature search was performed using keywords related to chronic kidney disease, uremic pruritus, dermatology, and omega-3 fatty acids across PubMed, Scopus, and Europe PMC databases. Omega-3 fatty acid supplementation resulted in a significant reduction in overall pruritus severity compared with placebo or vegetable oil interventions. Higher-quality and more standardized studies are required before routine omega-3 fatty acid supplementation can be recommended. However, preliminary evidence suggests that omega-3 supplementation may be beneficial in reducing pruritus severity among patients with CKD-aP.

INTRODUCTION

Pruritus is an unpleasant skin sensation that triggers the urge to scratch (Song et al., 2018). Uremic pruritus (UP), also known as chronic kidney disease-associated pruritus (CKD-aP), is one of the most common and distressing symptoms experienced by patients with end-stage renal disease (ESRD), with uremia indicating impaired kidney function (Mettang & Kremer, 2015). Recent epidemiological data suggest that approximately 40% of patients with ESRD experience moderate to severe itching (Combs et al., 2015). This symptom is particularly troublesome among patients undergoing peritoneal dialysis (PD) or hemodialysis (HD). A Taiwanese study reported pruritus prevalence rates of 38.2% among HD patients and 28.6% among PD patients, with HD patients also experiencing more severe symptoms (Wu et al., 2016). The prevalence of UP ranges from 15–49% during the pre-dialysis stage and increases to 50–90% after dialysis initiation (Ozen et al., 2018).

The Dialysis Outcomes Practice Patterns Study (DOPPS), conducted between 2012 and 2015, found that 26% to 48% of patients experienced at least moderate skin itching, while 13% to 26% reported severe or extreme symptoms (Duplaga, 2015 — *[rujukan tidak sesuai topik; kemungkinan salah tautan]*). The condition often fluctuates over time, typically presenting as persistent or recurrent episodes that are bilaterally symmetrical and tend to worsen at night. Itching usually occurs daily and most frequently affects the trunk, limbs, face, and back. Environmental factors, such as heat and dryness, may intensify discomfort (Mettang & Kremer,

2015). UP has a substantial impact on quality of life (QOL), affecting sleep, mood, and social functioning, and is associated with compulsive scratching. Moreover, severe itching is an independent predictor of mortality among patients undergoing dialysis (Simonsen et al., 2017).

The underlying mechanisms of UP in chronic kidney disease (CKD) remain incompletely understood, although various theories have been proposed, suggesting a multifactorial pathogenesis (Yamamoto & Isaka, 2024; Zhang et al., 2025). Several contributing factors have been identified, including altered serum parathyroid hormone (PTH) levels and calcium (Ca)/phosphorus (P) metabolism, alterations in primary afferent sensory neurons or interneurons associated with neuropathy and dysautonomia, cutaneous or neuroinflammation-related chronic systemic inflammation, and increased μ - and κ -opioid receptor activity resulting from renal failure (Simonsen et al., 2017; Santos-Alonso et al., 2021). A recent study reported that pruritus may be induced through interactions among sensory neurons (proprioceptors), immune cells, and keratinocytes involved in maintaining the epithelial barrier (Garcovich et al., 2021).

Numerous studies have investigated treatments for CKD-aP; however, many are limited by methodological issues, including uncontrolled single-center designs, small sample sizes, and inconsistent approaches for assessing pruritus severity (Verduzco & Shirazian, 2020). Consequently, the availability of effective therapies remains limited, and the reliability of existing evidence is often compromised by inadequate reporting of baseline characteristics, comorbidities, concomitant medications, and limited participant numbers. Various interventions have been proposed to alleviate symptoms, including pharmacological approaches such as topical agents emollients, capsaicin, pramoxine, tacrolimus, saran, and gamma-linolenic acid as well as cannabinoids and systemic treatments, including antihistamines, cholestyramine, gabapentin, pregabalin, opioid receptor modulators (naltrexone, nalfurafine, pentoxifylline, difelikefalin, thalidomide, and naloxone), mast cell stabilizers (cromolyn sodium), and neurokinin-1 (NK-1) receptor inhibitors (serlopitant). In addition, nonpharmacological strategies have been reported, including ultraviolet light therapy, acupuncture, omega-3 fatty acid supplementation, turmeric consumption, low-protein diets, magnesium-free dialysis, aromatherapy, and physical exercise (Agarwal et al., 2021; Makar et al., 2021; Westby et al., 2020; Yeam et al., 2021).

A recent meta-analysis compared several treatments, including gabapentin, pregabalin, ondansetron, antihistamines, opioids, and doxepin, and demonstrated that gabapentin had the most favorable effect for pruritus control (Feng et al., 2021). A study from Iraq reported that a combination of gabapentin 100 mg and 1,000 mg omega-3-based fish oil capsules containing 120 mg of DHA and 180 mg of EPA was more effective in reducing pruritus severity than either treatment alone among Iraqi patients (Hussein et al., 2018).

Omega-3 fatty acids have been proposed as a potential treatment for UP by addressing essential fatty acid deficiency and reducing inflammatory responses. These fatty acids are converted into eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), which, through cyclooxygenase and lipoxygenase pathways, contribute to the production of anti-inflammatory prostaglandins and leukotrienes. Emerging research indicates that omega-3 supplementation increases EPA and DHA levels while simultaneously reducing the concentration of omega-6 fatty acids, such as arachidonic acid, within plasma membranes (Ghanei et al., 2012).

ESRD patients often exhibit altered fatty acid profiles. Deficiency in essential fatty acids (EFAs) can lead to various dermatological manifestations, including dry skin (xerosis), scaly erythematous rashes, erosions in skin folds, delayed wound healing, purpura due to fragile capillaries, brittle nails, hair loss, and alterations in hair pigmentation, including both darkening and lightening. Beyond cutaneous manifestations, associated systemic effects include hepatic steatosis, increased susceptibility to infection, impaired immune function, anemia, thrombocytopenia, and growth impairment (Yan, 2019). A pilot study suggested that omega-3 supplementation may alleviate pruritus in patients undergoing continuous ambulatory peritoneal dialysis (CAPD), with the antipruritic effects likely resulting from improved regulation of skin hydration (Lahiji et al., 2018). In a study by Barcelos et al., (2015) animal models demonstrated that 60 to 90 days of fish oil supplementation at 3 g/kg/day reduced transepidermal water loss and improved skin hydration. These effects were associated with increased omega-3 fatty acid levels in the skin and a reduced omega-6 to omega-3 fatty acid ratio (<5) in acetone extracts, which subsequently decreased scratching behavior induced by dry skin (Barcelos et al., 2015).

Given the previous evidence highlighting the potential role of omega-3 fatty acids in reducing pruritus, this review aims to examine the clinical benefits of omega-3 supplementation in managing CKD-associated pruritus (CKD-aP).

The search process included all clinical trials with a prospective design that investigated the effects of omega-3 supplementation on CKD-aP. A comprehensive literature search was conducted in April 2022 using PubMed, Scopus, and Europe PMC databases. The search strategy included terms related to CKD (including kidney failure, end-stage renal disease, dialysis, hemodialysis [HD], and peritoneal dialysis [PD]), uremic pruritus (UP) (including itching, xerosis, and skin-related disorders), dermatological conditions, and omega-3 fatty acids (including fish oil, n-3 fatty acids, alpha-linolenic acid (ALA), polyunsaturated fatty acids, docosahexaenoic acid (DHA), and eicosapentaenoic acid (EPA)). In addition, the researchers manually screened the reference lists of the selected articles.

Several previous studies have examined the effectiveness of omega-3 supplementation for UP in dialysis patients, although the findings have been inconsistent. Begum et al. (2004) conducted a prospective, double-blind, randomized study involving 22 HD patients who received fish oil (omega-3) or safflower oil (omega-6) supplementation for 16 weeks. The results demonstrated a significant reduction in itching frequency in the omega-3 group ($P < 0.05$), with an overall pruritus score reduction of 41.3% compared with 10.1% in the omega-6 group. However, the difference between groups was not statistically significant, which the researchers attributed to the limited sample size.

Ghanei et al. (2012) reported that daily oral supplementation with 3 g of fish oil (containing 540 mg EPA and 360 mg DHA) for 20 days among 22 HD patients resulted in a significant reduction in UP symptoms compared with placebo (65% improvement in the omega-3 group versus 15% in the placebo group, $P < 0.0001$). Similarly, Lahiji et al. (2018) demonstrated that among 40 PD patients, daily consumption of 3 g of fish oil for four weeks produced a significantly greater reduction in mean pruritus scores compared with placebo ($P < 0.001$).

However, Fiedler et al. (2005), in an uncontrolled prospective pilot study involving 11 HD patients who received 1.2 g of omega-3 and 11.2 g of pectin daily for 12 weeks, found no

significant improvement in pruritus symptoms. These inconsistent findings highlight the need for a more comprehensive synthesis of available evidence.

Although several studies have investigated the effectiveness of omega-3 supplementation for UP, several research gaps remain. First, most studies have been limited by small sample sizes and heterogeneous study designs, making it difficult to establish definitive conclusions. Second, the mechanisms underlying the antipruritic effects of omega-3 fatty acids remain incompletely understood, particularly regarding their influence on specific inflammatory pathways in dialysis patients. Third, no comprehensive literature review has synthesized the available clinical evidence regarding the effectiveness of omega-3 supplementation for CKD-aP, including its potential mechanisms, clinical outcomes, and consistency across studies.

The novelty of this literature review lies in its attempt to systematically synthesize available clinical evidence from prospective studies evaluating omega-3 supplementation for CKD-aP, an area that has not been comprehensively reviewed to date. This review also aims to identify important research gaps while providing a mechanistic framework linking the anti-inflammatory properties of omega-3 fatty acids with improvements in pruritus symptoms among dialysis patients. Therefore, this review is expected to provide evidence-based insights for clinicians and researchers in the fields of nephrology and dermatology.

The objective of this literature review is to examine the clinical benefits of omega-3 supplementation in managing CKD-aP among dialysis patients. Specifically, this review aims to identify the mechanisms through which omega-3 fatty acids may reduce pruritus, evaluate their effectiveness based on available prospective clinical studies, and assess the consistency of findings across studies while exploring factors that may contribute to variations in outcomes. This literature review provides evidence-based guidance for clinicians considering omega-3 supplementation as an adjunctive therapy for uremic pruritus, highlights a potential nutritional intervention for patients, identifies priorities for future research, and supports the development of clinical recommendations for policymakers, ultimately contributing to improved holistic care for patients with CKD.

METHOD

This study employed a literature review design by systematically identifying and reviewing prospective clinical trials that examined the effects of omega-3 fatty acid supplementation on CKD-aP. A comprehensive literature search was conducted in April 2022 using three electronic databases: PubMed, Scopus, and Europe PMC. The search strategy used a combination of keywords covering three main domains: CKD-related terms (kidney failure, CKD, ESRD, dialysis, HD, and PD), UP-related terms (itching, pruritus, xerosis, and dermatological conditions), and omega-3 fatty acid-related terms (fish oil, omega-3 fatty acids, n-3 fatty acids, alpha-linolenic acid [ALA], polyunsaturated fatty acids, docosahexaenoic acid [DHA], and eicosapentaenoic acid [EPA]). Boolean operators (AND and OR) were applied to optimize the sensitivity of the search strategy.

Studies were included if they met the following criteria: (1) published in English; (2) used a prospective clinical trial design, including randomized controlled trials (RCTs) or prospective pilot studies; (3) involved adult patients with CKD undergoing hemodialysis or peritoneal dialysis; (4) evaluated omega-3 fatty acid supplementation as an intervention; and (5) assessed pruritus outcomes using measurable or validated assessment methods. Studies were excluded

if they were case reports, case series, review articles, animal studies, or did not report pruritus-related outcomes. In addition, the reference lists of the included studies were manually screened to identify additional relevant studies.

Data extraction was performed independently by the authors. The extracted data included study design, sample size, patient characteristics, type and dosage of omega-3 supplementation, intervention duration, comparison groups, pruritus assessment methods, and main findings related to pruritus outcomes. The methodological quality and potential risk of bias were assessed narratively based on the reporting of randomization, blinding, control groups, and sample size adequacy. A meta-analysis was not performed due to substantial heterogeneity among the included studies in terms of study design, participant characteristics, intervention protocols, and pruritus assessment methods.

RESULTS AND DISCUSSION

Begum et al. (2004) conducted a randomized, prospective, double-blind study to evaluate how supplementation with oils rich in long-chain fatty acids specifically fish oil (FO) and safflower oil (SO) affects leukotriene B4 (LTB4) production by polymorphonuclear leukocytes (PMNLs) and pruritus symptoms in HD patients. Twenty-two participants were assigned to take either six FO capsules daily (728 mg omega-3 per capsule) or six SO capsules (704 mg omega-6 per capsule) over 16 weeks. By the end of the trial, red blood cell phospholipid analysis showed that FO significantly raised total omega-3 levels and the omega-3 to omega-6 ratio compared to SO. LTB4 production decreased in both groups, but the decline was greater in the FO group. Although baseline pruritus scores were similar across groups, the frequency of itching dropped significantly more in the FO group ($P < 0.05$). The overall pruritus score also favored FO, with a 41.3% reduction versus 10.1% in the SO group—a difference that may be clinically meaningful despite lacking statistical significance. The researchers attributed this outcome partly to the small sample size and limited statistical power. Moreover, the improvement in itching did not align directly with changes in LTB4 levels, suggesting other inflammatory agents, such as serotonin, histamine, proteases, or platelet-activating factor might be involved. The study also did not account for other contributors to pruritus, including uremic toxins, hyperparathyroidism, or calcium-phosphate imbalances. The authors noted additional limitations: the assay's LTB4 antibody had 100% cross-reactivity with LTB5, making it impossible to detect potential increases in LTB5 if omega-3 fatty acids had replaced omega-6 in cell membranes. Furthermore, the impact of omega-3 supplementation might have been masked by a background diet high in omega-6 fatty acids. Lastly, the study found no distinct effect of FO on leukotriene production by PMNLs, meaning it did not capture any true inhibition of lipoxygenase activity.

In a separate study, Fiedler and colleagues (2005) conducted a prospective, uncontrolled pilot trial to assess the impact of omega-3 fatty acid supplementation on several parameters in hemodialysis (HD) patients. These included C-reactive protein (CRP), homocysteine, lipoproteins, complement factors, blood gas levels, oxygen saturation, blood pressure, heart rate variability, ECG results, shunt flow and recirculation, and pruritus. The trial involved eleven non-diabetic HD patients with stable lipid profiles, who were given 1.2 g of omega-3 fatty acids along with 11.2 g of pectin each day over a 12-week period. Despite this intervention, no notable improvement in itching symptoms was detected.

However, Ghanei et al. (2012) research involving 22 hemodialysis patients found that daily oral supplementation with 3 g of FO providing 540 mg of EPA and 360 mg of DHA for 20 days led to a significant reduction in UP symptoms compared to placebo (65% improvement with omega-3 versus 15% with placebo, $P < 0.0001$). Similarly, Lahiji et al. (2018) included 40 peritoneal dialysis patients suffering from pruritus and showed that taking 3 g of FO daily (in 1-g capsules each containing 180 mg EPA and 120 mg DHA) for four weeks resulted in a significantly greater decrease in mean pruritus scores in the omega-3 group compared to placebo ($p < 0.001$ at four weeks post-intervention). The beneficial antipruritic effects of omega-3 fatty acids in dialysis patients may also be linked to improved skin water homeostasis.

Interpretation

Chronic itching involves a complex and not fully understood pathophysiology. Its onset is primarily linked to systemic immune reactions triggered by hemodialysis, which can lead to nociceptive signaling. Evidence supporting the inflammatory basis of this condition includes elevated levels of uremic toxins, C-reactive protein, interleukin (IL)-6, and IL-31 in hemodialysis patients experiencing pruritus. Additionally, the dialysis process itself may activate blood cells through interactions with dialysis membranes, prompting the release of itch-inducing cytokines and exacerbating symptoms. Pruritogens, substances such as histamine, prostaglandins, cytokines, neuropeptides, and proteases are released in the skin by keratinocytes, immune cells, or nearby nerve cells. These compounds stimulate primary sensory neurons, located in the dorsal root and trigeminal ganglia, via receptors including G protein-coupled, Toll-like, and interleukin receptors, acting through both histamine-dependent and independent pathways. Once activated, these neurons relay the itch signal to secondary neurons in the spinal cord's dorsal horn. There, spinal interneurons regulate the sensation using specific signaling molecules like natriuretic polypeptide B, before projection neurons carry the signal along the spinothalamic tract to the cerebral cortex for perception (Figure 1) (Verduzco & Shirazian, 2020; Martin et al., 2020; Cevikbas & Lerner, 2019).

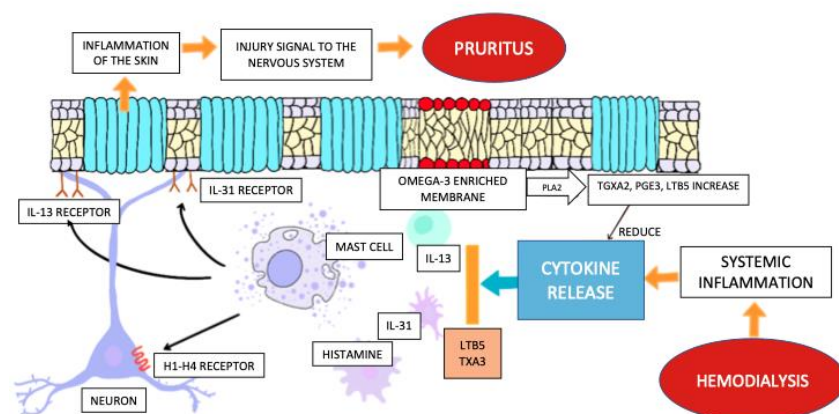


Figure 1. Hemodialysis increases systemic inflammation and elicit cytokine release inducing mast cell to induce IL-13 and IL-31 as well as H1-H4 receptors inducing skin inflammation and signaling injury to the nervous system causing pruritus. Omega-3 through its mechanism in TGXA2, PGE3, and LTBS reduce cytokine release thus reducing pruritus.

Source: Adapted from Verduzco & Shirazian (2020), Martin et al. (2020), Cevikbas & Lerner (2019), and Ghanei et al. (2012)

A variety of pruritogens, receptors, neurons, and neurotransmitters play a role in the development of itching, and it's probable that distinct itch conditions involve specific combinations of cells and molecules responsible for transmitting itch signals. In pruritus, activation of itch-sensitive receptors in the skin or peripheral nerve endings produces signals that travel to the central nervous system through C-fibers. Endogenous opioids can trigger mast cells, leading to histamine release and adverse reactions like hives and increased heart rate. Disruptions in the balance and activity of opioid receptors, found in skin cells, immune cells, peripheral nerves, and the brain, can intensify itching and increase the tendency to scratch (Verduzco & Shirazian, 2020; Martin et al., 2020; Cevikbas & Lerner, 2019).

Bioactive fatty acids derived from FO, especially EPA and DHA, offer numerous health advantages for individuals with ERD. In the broader population, omega-3 polyunsaturated fatty acid (PUFA) supplementation has shown potential in influencing various disease mechanisms, such as inflammation and immune responses, the development of atherosclerosis and cardiovascular conditions, cardiac arrhythmias, high blood pressure, and abnormal lipid levels. However, despite these possible benefits, omega-3 supplements are not commonly used or routinely advised for people with CKD. Research has explored the positive clinical effects of omega-3 fatty acids in several health conditions particularly relevant to dialysis patients. Omega-3 fatty acids are a class of polyunsaturated fats characterized by two or more double bonds, with one situated three carbons from the methyl end—hence the term “omega-3” or “n-3.” The primary omega-3 PUFA, ALA, is primarily obtained from plant-based oils. Within the endoplasmic reticulum, ALA is transformed through desaturase and elongase enzymes into the longer-chain EPA. EPA is then further elongated and desaturated in peroxisomes through a complex sequence known as the Sprecher pathway, resulting in limited production of DHA. EPA and DHA are the most biologically active and widely studied forms of omega-3 fatty acids. Recent findings indicate that omega-3 supplementation raises levels of EPA and DHA while reducing the presence of omega-6 fatty acids, like arachidonic acid, in cell membranes. The anti-inflammatory properties of omega-3 fatty acids have been linked to clinical improvements in certain skin conditions, including psoriasis and urticarial rashes caused by salicylates. Additionally, studies in animal models specifically rats with acetone-induced dry skin have confirmed that oral omega-3 supplementation can reduce itching and improve skin hydration, suggesting potential benefits for dialysis patients experiencing similar symptoms.

Although, one meta-analysis comparing treatments such as gabapentin, pregabalin, ondansetron, antihistamines, opioids, and doxepin found that gabapentin was the most effective for managing pruritus (Feng et al., 2021). However, a study conducted in Iraq indicated that combining gabapentin (100 mg) with FO capsules containing 1000 mg omega-3 specifically 120 mg DHA and 180 mg EPA was more effective in reducing pruritus than either treatment alone in Iraqi patients (Hussein et al., 2018).

Three research have found that chronic kidney disease (CKD) patients who took omega-3 supplements experienced a notable reduction in pruritus compared to those given omega-6, omega-9, or a placebo (Ghanei et al., 2012; Lahiji et al., 2018; Begum et al., 2004). In contrast, a small pilot study without a control group did not find a clear benefit of omega-3 supplementation for UP symptoms (Fiedler et al., 2005).

Given the high prevalence of pruritus in uremic patients and the absence of a definitive treatment, along with evidence of altered essential fatty acid profiles in these individuals and their potential role in the development of UP, FO supplementation may offer a beneficial effect.

CONCLUSION

Omega-3 supplementation has demonstrated potential to modulate inflammatory responses and immune function. Essential fatty acid supplementation has been shown to alleviate pruritus symptoms in CKD-aP through multiple mechanisms, particularly in patients who have limited responses to standard antipruritic therapies. However, evidence regarding the effectiveness of omega-3 supplementation remains limited, and further standardized studies are needed to elucidate its mechanisms of action and determine whether routine omega-3 supplementation should be recommended. Clinicians may consider omega-3 supplementation as an adjunctive therapy for refractory pruritus when conventional treatments are insufficient. Future research should focus on large-scale randomized controlled trials (RCTs) with standardized outcome measures to establish optimal dosage, treatment duration, and safety profiles. Policymakers may consider incorporating omega-3 supplementation into CKD-aP management guidelines, while patients should consult healthcare providers before initiating supplementation.

REFERENCES

- Agarwal, P., Garg, V., Karagaiah, P., Szepietowski, J. C., Grabbe, S., & Goldust, M. (2021). Chronic kidney disease-associated pruritus. *Toxins*, 13(8), 527. <https://doi.org/10.3390/toxins13080527>
- Barcelos, R. C., de Mello-Sampayo, C., Antoniazzi, C. T., Segat, H. J., Silva, H., Veit, J. C., Piccolo, J., Emanuelli, T., Bürger, M. E., Silva-Lima, B., & Rodrigues, L. M. (2015). Oral supplementation with fish oil reduces dryness and pruritus in the acetone-induced dry skin rat model. *Journal of Dermatological Science*, 79(3), 298–304. <https://doi.org/10.1016/j.jdermsci.2015.06.015>
- Begum, R., Belury, M. A., Burgess, J. R., & Peck, L. W. (2004). Supplementation with n-3 and n-6 polyunsaturated fatty acids: Effects on lipoxygenase activity and clinical symptoms of pruritus in hemodialysis patients. *Journal of Renal Nutrition*, 14(4), 233–241.
- Cevikbas, F., & Lerner, E. A. (2019). Physiology and pathophysiology of itch. *Physiological Reviews*. <https://doi.org/10.1152/physrev.00017.2019>
- Combs, S. A., Teixeira, J. P., & Germain, M. J. (2015). Pruritus in kidney disease. *Seminars in Nephrology*, 35(4), 383–391. <https://doi.org/10.1016/j.semnephrol.2015.06.009>
- Duplaga, M. (2015). A cross-sectional study assessing determinants of the attitude to the introduction of eHealth services among patients suffering from chronic conditions. *BMC Medical Informatics and Decision Making*, 15, 33. <https://doi.org/10.1186/s12911-015-0157-3>
- Feng, W. W., Yuan, B., Shen, F. Y., Fan, W. Y., Mei, D. S., Bao, B. Y., & Chen, Q. J. (2021). Efficacy of uremic pruritus treatment in patients undergoing hemodialysis: A network meta-analysis for randomized clinical trials. *Néphrologie & Thérapeutique*, 17(1), 30–34. <https://doi.org/10.1016/j.nephro.2020.09.006>
- Fiedler, R., Mall, M., Wand, C., & Osten, B. (2005). Short-term administration of omega-3 fatty acids in hemodialysis patients with balanced lipid metabolism. *Journal of Renal Nutrition*, 15(2), 253–256. <https://doi.org/10.1053/j.jrn.2005.01.007>

- Garcovich, S., Maurelli, M., Gisondi, P., Peris, K., Yosipovitch, G., & Girolomoni, G. (2021). Pruritus as a distinctive feature of type 2 inflammation. *Vaccines*, 9(3), 303. <https://doi.org/10.3390/vaccines9030303>
- Ghanei, E., Zeinali, J., Borghei, M., & Homayouni, M. (2012). Efficacy of omega-3 fatty acids supplementation in treatment of uremic pruritus in hemodialysis patients: A double-blind randomized controlled trial. *Iranian Red Crescent Medical Journal*, 14(9), 515–522.
- Hussein, S., Kadhim, K., Sultani, A., & Hussain, S. (2018). Evaluation of the role of gabapentin and/or omega-3 in uremic pruritus for patients undergoing hemodialysis. *International Journal of Research in Pharmaceutical Sciences*, 9, 10.26452/ijrps.v9iSPL1.1406. <https://doi.org/10.26452/ijrps.v9iSPL1.1406>
- Lahiji, A. P., Mortazavi, M., Tirani, S. A., Moeinzadeh, F., Bidaki, E. Z., Naini, A. E., Faghihi, G., Toghyani, A., & Farajzadegan, Z. (2018). Omega-3 supplementation improves pruritus in continuous ambulatory peritoneal dialysis patients: A crossover randomized pilot clinical trial. *Journal of Research in Pharmacy Practice*, 7(4), 195–199. https://doi.org/10.4103/jrpp.JRPP_18_64
- Makar, M., Smyth, B., & Brennan, F. (2021). Chronic kidney disease-associated pruritus: A review. *Kidney and Blood Pressure Research*, 46(6), 659–669. <https://doi.org/10.1159/000518391>
- Martin, C. E., Clotet-Freixas, S., Farragher, J. F., & Hundemer, G. L. (2020). Have we just scratched the surface? A narrative review of uremic pruritus in 2020. *Canadian Journal of Kidney Health and Disease*, 7, 2054358120954024. <https://doi.org/10.1177/2054358120954024>
- Mettang, T., & Kremer, A. E. (2015). Uremic pruritus. *Kidney International*, 87(4), 685–691. <https://doi.org/10.1038/ki.2013.454>
- Ozen, N., Cinar, F. I., Askin, D., & Mut, D. (2018). Uremic pruritus and associated factors in hemodialysis patients: A multi-center study. *Kidney Research and Clinical Practice*, 37(2), 138–147. <https://doi.org/10.23876/j.krcp.2018.37.2.138>
- Santos-Alonso, C., Maldonado Martín, M., Sánchez Villanueva, R., Álvarez García, L., Vaca Gallardo, M. A., Bajo Rubio, M. A., Del Peso Gilsanz, G., Ossorio González, M., & Selgas Gutiérrez, R. (2021). Pruritus in dialysis patients: Review and new perspectives. *Nefrología*, 41(3), 233–245. <https://doi.org/10.1016/j.nefro.2020.12.010>
- Simonsen, E., Komenda, P., Lerner, B., Askin, N., Bohm, C., Shaw, J., Tangri, N., & Rigatto, C. (2017). Treatment of uremic pruritus: A systematic review. *American Journal of Kidney Diseases*, 70(5), 638–655. <https://doi.org/10.1053/j.ajkd.2017.05.018>
- Song, J., Xian, D., Yang, L., Xiong, X., Lai, R., & Zhong, J. (2018). Pruritus: Progress toward pathogenesis and treatment. *BioMed Research International*, 2018, 9625936. <https://doi.org/10.1155/2018/9625936>
- Westby, E. P., Purdy, K. S., & Tennankore, K. K. (2020). A review of the management of uremic pruritus: Current perspectives and future directions. *Itch*, 5(3), e38. <https://doi.org/10.1097/itx.0000000000000038>
- Wu, H. Y., Peng, Y. S., Chen, H. Y., Tsai, W. C., Yang, J. Y., Hsu, S. P., Pai, M. F., Lu, H. M., Chiang, J. F., Ko, M. J., Wen, S. Y., & Chiu, H. C. (2016). A comparison of uremic pruritus in patients receiving peritoneal dialysis and hemodialysis. *Medicine*, 95(9), e2935. <https://doi.org/10.1097/MD.0000000000002935>
- Yan, A. C. (2019). Cutaneous changes in nutritional disease. In S. Kang, M. Amagai, A. L. Bruckner, A. H. Enk, D. J. Margolis, A. J. McMichael, & J. S. Orringer (Eds.), *Fitzpatrick's dermatology* (9th ed.). McGraw Hill. <https://accessmedicine.mhmedical.com/content.aspx?bookid=2570§ionid=210437119>
- Yamamoto, T., & Isaka, Y. (2024). Pathological mechanisms of kidney disease in ageing.

- Nature Reviews Nephrology*, 20(9), 603–615.
- Yeam, C. T., Yo, T. E., Tan, Y. L. C., Liew, A., & Seng, J. J. B. (2021). Complementary and alternative medicine therapies for uremic pruritus: A systematic review of randomized controlled trials. *Complementary Therapies in Medicine*, 56, 102609. <https://doi.org/10.1016/j.ctim.2020.102609>
- Zhang, H., Wang, K., Zhao, H., Qin, B., Cai, X., Wu, M., Li, J., & Wang, J. (2025). Diabetic kidney disease: from pathogenesis to multimodal therapy—current evidence and future directions. *Frontiers in Medicine*, 12, 1631053.