Clinical Kidney Journal, 2022, vol. 15, no. 10, 1829–1837

https://doi.org/10.1093/ckj/sfac102
Advance Access Publication Date: 19 April 2022
CKJ Review

CKJ REVIEW

Home-delivered meals as an adjuvant to improve volume overload and clinical outcomes in hemodialysis

Luis M. Perez [1,2], Annabel Biruete [3,4] and Kenneth R. Wilund [2,5]

[1]Division of Renal Disease and Hypertension, University of Colorado Anschutz Medical Campus, Denver, CO, USA, [2]Division of Nutritional Sciences, University of Illinois at Urbana-Champaign, Urbana, IL, USA, [3]Department of Nutrition and Dietetics, Indiana University-Purdue University Indianapolis, Indianapolis, IN, USA, [4]Division of Nephrology, Indiana University School of Medicine, Indianapolis, IN, USA and [5]Department of Kinesiology and Community Health, University of Illinois at Urbana-Champaign, Urbana, IL, USA

Correspondence to: Kenneth R. Wilund; E-mail: kwilund@illinois.edu

ABSTRACT

Patients on chronic hemodialysis are counseled to reduce dietary sodium intake to limit their thirst and consequent interdialytic weight gain (IDWG), chronic volume overload and hypertension. Low-sodium dietary trials in hemodialysis are sparse and mostly indicate that dietary education and behavioral counseling are ineffective in reducing sodium intake and IDWG. Additional nutritional restrictions and numerous barriers further complicate dietary adherence. A low-sodium diet may also reduce tissue sodium, which is positively associated with hypertension and left ventricular hypertrophy. A potential alternative or complementary approach to dietary counseling is home delivery of low-sodium meals. Low-sodium meal delivery has demonstrated benefits in patients with hypertension and congestive heart failure but has not been explored or implemented in patients undergoing hemodialysis. The objective of this review is to summarize current strategies to improve volume overload and provide a rationale for low-sodium meal delivery as a novel method to reduce volume-dependent hypertension and tissue sodium accumulation while improving quality of life and other clinical outcomes in patients undergoing hemodialysis.

Keywords: dietary sodium, hemodialysis, interdialytic weight gain, kidney failure, meal delivery, nutrition, quality of life, volume overload

INTRODUCTION

Chronic volume overload is a persistent and challenging problem in kidney failure patients undergoing chronic hemodialysis (HD) therapy, with an estimated prevalence of 40–60% [1–4]. However, volume overload is rarely quantified in an objective manner, as there are several assessment techniques but no universal standard diagnosis for volume overload in either clinical practice or research [5]. Chronic volume overload contributes to a poor quality of life, caused in part by edema, fatigue, impaired breathing and poor dialysis treatment tolerance [6]. Chronic volume overload also contributes to hypertension and left ventricular hypertrophy, which are leading causes of morbidity and mortality in patients undergoing HD [7–10].

Volume overload and hypertension are managed through a combination of pharmacological therapy, dialysis therapy and

Received: 1.2.2022; Editorial decision: 28.3.2022

lifestyle modifications that include dietary sodium restriction [11]. Dietary sodium intake, which stimulates thirst and subsequent fluid intake, is a primary cause of volume overload in HD patients with minimal to no residual kidney function [12]. However, antihypertensive medications are typically the first-line approach for treating hypertension aside from the prescribed dialysis treatment [13]. This is perhaps because modifying a patient's dietary sodium and fluid intake demands behavioral intervention strategies that require more effort than most clinicians are able to provide or that are sustainable [14]. Nonetheless, the limitations of pharmacological and dialysis therapy make sodium restriction critical to preventing and treating volume overload and hypertension in HD patients [15].

Seminal work in the USA from the 1960s [16–19], as well as more recent studies in Tassin, France [20] and Izmir, Turkey [21] have shown that blood pressure (BP) can be controlled in many HD patients nonpharmacologically using comprehensive volume control strategies that include significant restrictions in dietary sodium intake (e.g. <2000 mg/day) in conjunction with gradual or progressive ultrafiltration and reduced reliance on antihypertensive medications [2, 22]. These data suggest that sodium restriction is key to successful volume control and improving patients' quality of life and cardiovascular risk. This is further illustrated by single-intervention therapies, such as pharmacotherapy or altering dialysis parameters (e.g. increasing ultrafiltration rate and reducing dialysate sodium), that have shown limited efficacy in treating volume overload when not coupled with sodium restriction [21, 23–25]. Unfortunately, nonpharmacological lifestyle approaches to managing volume and hypertension in patients undergoing HD do not appear to be the primary focus and effort of clinical practice today [26].

One likely reason that comprehensive volume control protocols are not widely practiced is because it is challenging to reduce dietary sodium intake, a vital component of volume control. Low-sodium dietary trials in HD are sparse and mostly indicate that dietary education and behavioral counseling are ineffective in reducing sodium intake and interdialytic weight gain (IDWG) [27]. These research gaps suggest that new strategies for reducing dietary sodium intake are needed. One sodium reduction strategy that has shown promise in patients with hyperlipidemia, hypertension and heart failure is providing patients with low-sodium, home-delivered meals [28–30]. These comorbidities are often prevalent in patients on HD, which furthers the rationale for utilizing this approach in HD. Until recently [31], studies have not evaluated the efficacy of this approach to reduce sodium intake in HD patients.

Another reason to reduce excess sodium consumption is to potentially reduce sodium accumulation in soft tissues, which is elevated in patients on HD compared with healthy controls [32, 33]. Excess tissue sodium may contribute to cardiovascular complications, including hypertension, left ventricular hypertrophy and congestive heart failure [34, 35]. Although tissue sodium may be reduced to some extent during dialysis [33], studies have not investigated whether reducing dietary sodium intake can lead to reductions in the tissue sodium storage of HD patients.

Reduction of dietary sodium intake through low-sodium, home-delivered meals may lower tissue sodium accumulation and improve chronic volume overload, both factors that have been associated with hypertension, left ventricular hypertrophy and mortality in individuals on HD. Importantly, home meal delivery could bypass many of the barriers associated with a low-sodium diet in patients on HD. Home-delivered meals also have the potential to be formulated to be low in phosphorus and potassium, which could have secondary benefits in the context of highly complex renal dietary restrictions [36]. The objective of this review is to summarize current strategies to improve volume overload and provide a rationale for low-sodium meal delivery as a novel method to reduce volume-dependent hypertension and tissue sodium accumulation while improving quality of life and other clinical outcomes in individuals undergoing HD.

Rationale for sodium restriction as the primary focus of volume control

The prevalence of volume overload is difficult to determine as clinical assessment relies on different subjective, objective and proxy measures of volume status [37]. Although many of these assessment techniques have different benefits and drawbacks, IDWG is arguably a highly informative and practical measure of fluid intake and retention (i.e. acute volume overload) in clinical practice [38]. To prevent volume overload, patients undergoing HD are often advised to reduce both their sodium (<2.3 g/day) [39] and fluid intake to limit IDWG. However, adherence to these recommendations is low [40]. Some researchers have argued that sodium restriction should be the central focus of volume reduction strategies rather than fluid restrictions, due to ethical concerns [38, 41] and clinical consequences of advising patients not to consume fluid when thirsty, including xerostomia and periodontal disease [42].

This ideological shift could be based on the rationale that dietary sodium intake is a driver of thirst, fluid intake and fluid retention [43]. A major consequence of kidney failure is the inability to concentrate and produce urine to remove both fluid and electrolytes, leaving thirst as the major osmoregulatory mechanism, which is higher in patients on HD compared with healthy controls [44]. Studies by Kusaba *et al.* [45] and Kim *et al.* [46] have demonstrated that those with kidney disease generally have less sodium taste sensitivity (i.e. are less able to recognize salty tastes) than healthy controls. Osmolytes other than sodium, such as urea and glucose, may also drive excessive thirst and studies have shown that patients with diabetes on HD have greater thirst than those without diabetes [47]. Finally, both xerostomia and thirst have been positively associated with IDWG [48, 49].

Reduction of tissue sodium

A relatively new concept in sodium regulation is the non-osmotic storage of sodium in tissues such as the skin and skeletal muscle [50]. Extrarenal sodium regulation, in the form of vascular vasodilation and lymphatic expansion, has been proposed to mobilize fluid and electrolytes throughout the body while clearing sodium storage reservoirs [51]. Recent studies indicate that tissue sodium accumulation is positively associated with age, diabetes, BP and left ventricular hypertrophy [34, 35]. Thus it appears that tissue sodium may be linked to both volume overload and hypertension. In kidney failure, non-osmotic sodium regulation may be the sole remaining buffering mechanism for dietary intake and homeostasis [51, 52]. Thus extrarenal storage and regulation provide further rationale for limiting exogenous sources of sodium and attenuating tissue sodium accumulation. To date, however, few studies have examined the relationship between tissue sodium levels and clinical outcomes in patients on HD.

A recent study by Dahlmann *et al.* [33] demonstrated that patients on HD have excessive sodium in their skin and skeletal muscle compared with age-matched healthy controls. This

Table 1. Comprehensive approaches to reduce volume overload and hypertension in HD

Author	Results
Charra *et al.* [54]	98.4% BP controlled 98.4% BP medication free Highest global HD survival rate
Kayikcioglu *et al.* [57]	82% BP controlled 93% BP medication free Reduced IDWG (~1.0 kg/day)* Reduced LVH (~15 g/m^2)*
Ozkahya *et al.* [58]	96% BP controlled and medication free
Ozkahya *et al.* [56]	Reduced IDWG (~5.1 kg/day)* Reduced LVMI (~70 g/m^2)* Reduced CTI (~11%)* Reduced hypotensive events
Raimann *et al.* [60]	Reduced systolic BP (16 ± 5 mmHg)* Reduced diastolic BP (7.2 ± 2.6 kg)* Reduced pre-HD weight (3.9 ± 2.6 kg)* Reduced post-HD weight (3.8 ± 2.6 kg)*
Perez *et al.* [61]	Trend for reduced 1 to 2-month IDWG (P = 0.05) Reduced EDW (mean −2.3 ± 3.9 kg)* Reduced volume overload (mean −1.3 ± 1.8 L)* Reduced BP medications (mean −1 ± 1)* No significant BP changes (maintained)

All included studies consisted of a low-sodium diet, progressive ultrafiltration and conventional (4-h) dialysis, with the exception of 8-h dialysis in Charra *et al.* [54]. *Statistically significant ($P < 0.05$). LVH, left ventricular hypertrophy; LVMI, left ventricular mass index; CTI, cardiothoracic index; EDW, estimated dry weight.

study also reported that HD treatment may acutely reduce tissue sodium levels by 19–27% [33]. Yet, studies have not yet examined the impact of diet or reduced sodium intake on tissue sodium storage. Currently there is an unclear relationship between tissue sodium accumulation and other factors impacting HD patients' excessive cardiovascular disease risk, including hypertension, chronic volume overload, arterial stiffness and systemic inflammation.

Sodium restriction as a cornerstone of comprehensive volume control

Comprehensive volume control is generally defined as any combination of gradual reductions in target dialysis weights, minimization of antihypertensive prescriptions, standardized dialysate sodium and weekly intradialytic counseling on dietary sodium intake and IDWG. While it appears that single-therapy interventions aimed at reducing volume overload and hypertension in HD have had limited success [23, 24], some studies have demonstrated success when sodium restriction has been included as a cornerstone in comprehensive volume control intervention strategies. These strategies also included stringent management of ultrafiltration rates and reduced reliance on BP medications (Table 1) [53–55]. Dialysis centers in Tassin, France have long practiced strict sodium restriction, which appears to result in improved outcomes. Compared with clinics in the USA, Tassin dialysis centers have reduced mortality rates by nearly 50%, as well as IDWG, volume overload and BP [53–55]. However, a caveat to the Tassin approach is that patients typically dialyze for up to 8 hours, as opposed to 3 to 4-hour dialysis sessions in the USA.

In contrast, dialysis centers in Izmir, Turkey adopted a similar strategy, albeit with thrice-weekly, 4-hour HD, as is common in the USA [21]. Despite the reduced dialysis treatment times, they were able to achieve similar results, including normal BP without antihypertensive medications in up to 95% of patients [2, 56–59]. One example of this was a cross-sectional comparison of two dialysis clinics in Turkey conducted by Kayikcioglu *et al.* [57]. One center-controlled BP using a comprehensive volume control strategy that included intensive ultrafiltration and dietary sodium restriction, while the second center-controlled BP with antihypertensive medications. Both centers had improvements in BP, but the comprehensive volume reduction strategy significantly reduced IDWG, hypertension and left-ventricular mass index.

Notably, both Tassin and Izmir achieved significant reductions in BP without antihypertensive medications in the majority of patients [59]. Comprehensive volume reduction strategies, combining sodium restriction and increased ultrafiltration, are not novel and were originally recommended in the early decades of dialysis [16–18]. However, there are few examples outside of Izmir and Tassin where this approach is being successfully applied today. Raimann *et al.* [60] conducted a pilot volume control intervention in the USA, modeled after the Izmir protocol. While they showed reductions in IDWG and BP, the study was presented as an abstract at a professional conference but was never published in a peer-reviewed journal, so it is difficult to draw definitive conclusions from the data.

Unfortunately, these studies are also lacking data on important clinical outcomes such as dietary intake and dietary patterns and objective measures of volume overload. To address this gap in knowledge, our group conducted a pilot volume control intervention that included dietary sodium restriction as part of a comprehensive volume control intervention [61]. Our findings included modest reductions in sodium intake and markers of volume overload (dialysis weights, extracellular fluid and calculate volume overload), as well as improved BP control. These data are generally consistent with recent studies demonstrating small changes in dietary sodium intake and IDWG in patients on HD provided with weekly nutritional education and counseling (Table 1) [61]. However, the benefits are modest compared with the robust improvements in BP and volume overload demonstrated in the studies in Tassin and Izmir. The failure to fully replicate these findings in the USA suggests that novel strategies to reduce sodium intake are needed. These modest improvements may also be a reflection the US food supply, with high availability of ultra processed foods high in sodium, which makes it much more difficult to adhere to lower sodium intakes compared with other regions. However, salt and sodium intake may be similar or even higher in other countries as evidenced by population studies in Turkey [62].

Limited efficacy of dietary sodium interventions

Sodium restriction in patients on HD is recognized as an important strategy to reduce fluid intake, IDWG, volume overload and hypertension [63]. Many studies in HD patients have indicated that dietary sodium consumption exceeds the recommendations [39], with intakes that typically range from 2 to 14 g/day of sodium [64–71]. Unfortunately, strategies to reduce dietary sodium intake in patients undergoing HD have had little success [27]. Renal dietitians provide regular counseling to patients on HD to reduce their dietary sodium and fluid intake, but patient adherence to these recommendations remains low [14, 72]. This is further highlighted by several dietary education

Table 2. Studies investigating the effect of low-sodium/salt diet on IDWG in HD patients

Author, Year	Design, N	Intervention	Result (change)	Effect Size (Cohen's d)
Perez *et al.* [31], 2020	Single arm, 20	Usual diet followed by low-sodium delivered meals, 4-weeks pre versus 4-weeks post	Na intake Δ: -1.6 ± 0.3 g/day,* IDWG Δ: -0.8 ± 0.1 kg*	Na: 1.71, IDWG: 0.53
Sakai *et al.* [71], 2017	Single arm, 48	Usual diet followed by counseling, 48-months pre versus 48-months post	Na intake Δ: -0.6 ± 0.2 g/day,*[a] IDWG (kg) not reported	Na: 0.60
Sevick *et al.* [70], 2016	RCT, CON: 86 INT: 93	Counseling or counseling + technology support, 16 weeks	No Δ: dietary Na intake, No Δ: IDWG	Na: 0.00, IDWG: 0.18
Rodriguez-Telini *et al.* [69], 2014	RCT, CON: 18 INT: 21	Usual diet or usual diet less 2 g/Na/day, 16 weeks	Na intake Δ: -2.5 ± 0.4 g/day,* No Δ: IDWG	Na: 1.92, IDWG: 0.24
Maduell *et al.* [67], 2000	Case–control, 15	Nutritional counseling	Na intake Δ: -1.2 ± 1.2 g/day,* IDWG Δ: -0.5 ± 0.6 kg*	Na: 1.07, IDWG: 0.82
Rigby-Mathews *et al.* [68], 1999	RCCT, 28	Usual diet or 0.5 g/Na/day, 1 week	Na intake Δ: -2.7 ± 0.2g/Na/day,* IDWG Δ: $-0.8 + 0.2$ kg*	Na: 3.30, IDWG: 0.77

*Statistically significant ($P < 0.05$). [a]Within-subjects statistical comparison non significant ($P > 0.05$) or not reported. All values standardized from salt intake to Na content. Smallest effect size calculated based the lowest reported change values. Adapted from Bossola *et al.* (2018) [27]. Na, sodium; RCT, randomized control trial; RCCT, randomized control cross-over trial; IDWG, interdialytic weight gain; CON, control group; INT, intervention group.

or behavioral interventions that have not achieved or sustained significant reductions in both dietary sodium intake and IDWG (Table 2) [67–71].

Notably, Maduell *et al.* [67] and Rigby *et al.* [68] conducted two small studies that demonstrated successful reductions in both dietary sodium intake and IDWG, yet neither has been published as a full-text original article (i.e. short communication and abstracts only). Importantly, Rigby *et al.* [68] provided a strict shopping list, daily diet plan and low-sodium foods throughout the intervention to increase adherence. The provision of food in these examples supports meal provision as a method to increase dietary adherence among patients with CKD. Such an approach also addresses concerns about patient food security and the costs of purchasing fresh foods or produce. Though some previous studies have reported on general barriers to low-sodium dietary adherence [73], few have studied or reported on cultural food barriers and food fatigue that may also play an important role in dietary adherence. Epidemiological data suggest that IDWG is positively associated with both sodium intake and poor health outcomes, yet few trials have successfully managed to reduce dietary sodium consumption in patients on HD [74–77]. Thus there is a critical need to develop new strategies that produce robust reductions in sodium intake and subsequent reductions in IDWG to improve volume overload and reduce cardiovascular mortality.

The rationale for providing home-delivered meals to patients on HD

Patients on HD face a plethora of barriers that make it extremely challenging for them to adhere to recommendations to significantly restrict their dietary sodium intake [12, 38, 78]. Commonly cited barriers include time constraints, fatigue related to dialysis treatments [78] and socioeconomic factors such as food cost and availability (Table 3) [79]. Many patients on HD may also lack cooking equipment, physical function and/or social support, which reduces their ability to cook their own food [78]. Poor nutrition and health literacy, an inability to track nutrients and feelings of deprivation also contribute to low adherence to the renal diet [78, 80]. Given all these barriers, it is clear why attempts to restrict dietary sodium intake through enhanced education and counseling alone have had limited success (Table 2) [67–71]. In contrast, providing home-delivered kidney-friendly meals may help mitigate many of the barriers to eating a low-sodium diet.

To examine the initial efficacy of this approach, we recently conducted a pilot study that provided home-delivered renal meals to 20 HD patients [31]. Participants were followed for a 4-week observational period followed by a 4-week interventional home-meal delivery period. In this study, HD patients who were provided the home-delivered meals had reductions in IDWG, ultrafiltration, BP, and volume overload. In secondary analyses of this study (unpublished), during the observation period, participants frequently consumed high-sodium, ultra-processed and processed foods and there was a high proportion of meals consumed away from the home [81]. The largest contributors to dietary sodium intake also contributed to higher phosphorus and potassium intakes. This could be secondary to the concurrent use of phosphorus, sodium and potassium additives in ultra processed foods, though the studies did not capture these data. Participants may have also changed their consumption of animal-based food products or dairy consumption, which needs to be further evaluated in future studies. We also found several deficits in sodium knowledge. However, participants generally scored high on most assessed educational areas. These data agree with a recent study by Betz *et al.* [82] finding that dietary knowledge was not associated with dietary intake. A common reported behavioral challenge was the HD diet and

Table 3. Potential benefits and concerns of home-delivered meals in kidney failure

Benefits	Concerns
Adherence and barriers:	Adherence and barriers:
Less reliance on the need for shopping and cooking	Not eating provided meals and meal fatigue
Improved food security	Consumption of high-Na food in addition to the meals provided
Promote changes in salt-taste sensitivity/preference to promote short- or long-term behavior change	Reduced cooking self-efficacy and storage requirements
	Reduced patient autonomy for meal decisions
	Culturally appropriate meals may not be available
Clinical benefits:	Clinical consequences
Reduced Na, K, P and thirst/fluid intake	Meals may not meet entire nutritional needs: energy, protein, micronutrients
Reduced volume overload, HTN, hyperkalemia, hyperphosphatemia	Need for additional oral nutritional supplements
Improved HD treatment efficacy and reduced HD adverse effects	
Diabetes- and heart-healthy meals could be formulated	
Long-term cost-effectiveness:	Up-front costs:
Reduced antihypertensive medications, phosphate binders, K binders and hospitalizations	Several hundred dollars/month/patient
Improved treatment compliance/fewer missed dialysis shifts	
Safe weight reduction to improve kidney transplantation eligibility	

Na, sodium; K, potassium; P, phosphorus; QOL, quality of life; HTN, hypertension.

fluid restrictions. In contrast, participants were generally confident in limiting salt shaker usage and salt intake overall despite nearly all being above dietary sodium recommendations (>2.3 g/day/sodium) [39].

Evidence from other clinical populations

Low-sodium meal provision has shown promise in individuals with hyperlipidemia, hypertension [28] and heart failure [29]. Troyer *et al.* [28] provided seven home-delivered meals per week for 12 months to older adults with cardiovascular disease. The primary finding was that providing meals adopting the Dietary Approach to Stop Hypertension (DASH) diet increased DASH accordance (adherence), indicating that this was both a feasible and efficacious approach. In patients with heart failure, Hummel *et al.* [29] randomized patients to usual care or three DASH meals per day for 4 weeks to post discharge patients with heart failure. Meal provision in this study appeared to improve the survey-evaluated clinical status, rate of rehospitalization and duration of rehospitalizations. Similarly, Kalogeropoulos *et al.* [30] randomized patients with heart failure to 1500 or 3000 mg sodium home-delivered meals for 12 weeks. The primary finding was that the meals were generally well tolerated without adverse safety or quality-of-life signals. Overall, these studies suggest that providing meals may be a practical method to achieve dietary adherence that may also translate to improved clinical outcomes in clinical populations. Both Hummel *et al.* [29] and Kalogeropoulos *et al.* [30] used the commercial vendor PurFoods (Ankeny, IA, USA; www. purfoods.com), which also provides meal options for HD patients. In our pilot trial in HD, with a similar home-delivered approach, participants had generally good meal adherence and improvements in some clinical outcomes such as IDWG, volume overload and BP [31]. To date, however, studies have not widely explored the efficacy of a meal-provision approach to manage sodium intake and clinical outcomes in HD patients.

Clinical benefits

In addition to helping overcome barriers to a low-sodium diet, home-delivered meals may also yield clinical benefits relevant to HD patients (Table 3). First, reducing sodium intake could reduce thirst, sodium and fluid retention (Figure 1). This decrease in thirst may, in turn, lead to reduced IDWG, volume overload and hypertension, which in the long term may translate into reductions in left ventricular hypertrophy, congestive heart failure and cardiovascular mortality. Second, reductions in IDWG may reduce complications from aggressive dialysis ultrafiltration such as intradialytic hypotension, cardiac stunning, peripheral organ ischemia, cramping and fatigue [83]. Reduction of intradialytic hypotension, as well as these complications, may improve mortality and improve patients' quality of life. Notably, dialysis centers in Tassin, France reduced mortality due to a drastic reduction in hypotensive episodes attributed to slower ultrafiltration rates [20].

Moreover, a low-sodium diet may also reduce tissue sodium levels and thus further reduce cardiovascular risk in HD patients. Some commercial vendors [29, 84] also provide kidney-friendly meal options that are low in potassium and phosphorus. Therefore, home-delivered meals may also help prevent and treat hyperkalemia and hyperphosphatemia through the reduction of highly bioavailable phosphate and potassium additives. These meals can also be formulated to provide both consistent and adequate energy and protein intake to promote reductions in protein-energy wasting. Similarly, the meals can be formulated to contain adequate amounts of dietary fiber from plant-based foods, which may be beneficial for the gastrointestinal microbiota, leading to lower production of microbially derived uremic toxins [85, 86]. Diabetes- and heart-healthy options may be available for patients with these comorbidities. Lastly, meal-provision may represent a method to provide more plant-based, Mediterranean, or DASH-type foods, which has been described as a research priority in HD to reduce intradialytic symptoms and the risk of fluid overload [87].

Concerns and costs

There are a number of concerns with home-delivered meals that need to be considered. One obvious concern is the up-front costs associated with providing these meals. Typically, most home-delivery meal services charge ∼$6–$14 per meal [84, 88], although this may vary significantly depending on the provider and/or type of meal provided. If a healthcare or insurance

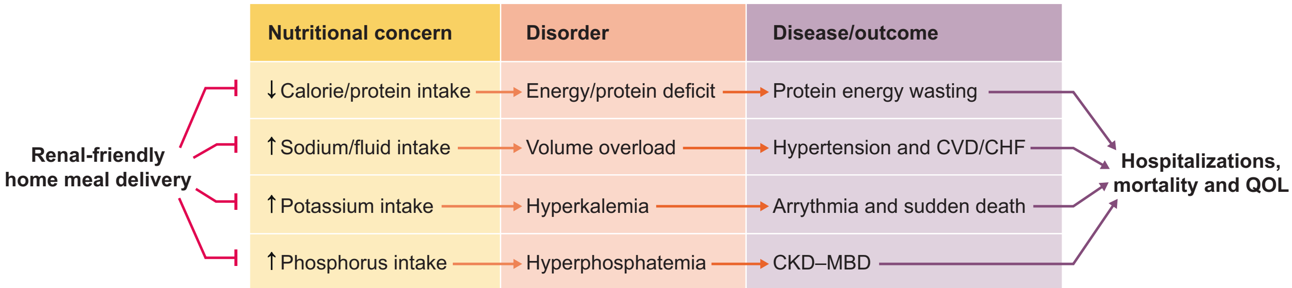

FIGURE 1: Potential benefits of home-delivered meals in patients with CKD. This figure depicts the potential benefits of kidney-friendly home-delivered meals. Meals can be formulated to be calorie dense and high protein to prevent protein energy malnutrition and wasting. Low-sodium meals may reduce thirst and fluid intake to improve volume-dependent hypertension. Low-potassium and low-phosphorus meals could improve hyperkalemia and hyperphosphatemia, in turn improving cardiac alterations and bone mineral disorders. CVD, cardiovascular disease; CHF, congestive heart failure; CKD-MBD, chronic kidney disease—mineral bone disorder; QOL, quality of life.

provider were to provide only two meals/patient/day, it would cost roughly $360–$840/patient/month, which is a significant cost outlay for a dialysis provider or insurance agency. However, home-delivered meals could also provide significant healthcare cost savings, especially if the reduced sodium intake helps manage chronic volume overload. Unfortunately, some parts of the world may not have insurance or dialysis providers to cover these costs. Individual patients would have to absorb these costs in these cases, which may not be possible for people with lower incomes. Nonetheless, an added benefit of meal provision is that there may be less need for some medications. For example, euvolemic patients may require fewer antihypertensive medications, while patients adhering to lower potassium and phosphorus intakes may need fewer intestinal potassium and phosphate binders. And most significantly, reduced volume overload, hyperkalemia and hyperphosphatemia should ideally lead to fewer hospitalizations. However, future long-term studies should assess the cost-effectiveness of this approach.

Three home-delivered dialysis-friendly meals would represent a minimum cost of ∼$587/month [89]. A proposed comparison of these costs would be approximately $6000 for a cardiovascular-related hospitalization, $300 for additional dialysis treatment and <$100/month for each pharmaceutical medication (antihypertensive agent, phosphate binder, potassium binder), though the cost-effectiveness of these treatments may be highly variable [90–96]. Meal provision could in theory also aid with weight loss in patients with obesity and in turn improve eligibility for kidney transplantation, which could help make the approach cost effective [97]. Overall, these effects could hypothetically also improve both quality and quantity of life, a benefit that could be desired by patients, healthcare providers, dialysis providers and insurance providers alike. But all of these hypotheses should be studied in a systematic way.

Patient receptiveness and practical considerations

Not all individuals will be equally receptive to home-delivered meals, nor will meals be equally beneficial to all patients. An important outcome in evaluating these hypotheses will be which HD patients may need this service long term versus those that may learn to change habits when provided low-sodium meals. Meal provision could be an effective method for ‘priming’ behavior change. Priming in this context would involve providing exposure to environmental cues that may help modify long-term behavior. A small body of literature suggests that priming strategies may improve specific nutrition behaviors, but this has not been studied as a strategy to reduce dietary sodium intake, particularly in HD patients [98]. This approach could assist patients in visualizing and controlling portion sizes to further aide in dietary sodium reduction. Some studies indicate that it may take several weeks to months on a low-sodium diet to change salt sensitivity and preferences [99]. As a result, providing home-delivered low-sodium meals for a short time (∼2–4 months) may help facilitate long-term changes in sodium intake and be less cost prohibitive. Nonetheless, it is important to investigate the midterm and long-term efficacy, benefits and cost-effectiveness of home-delivered meals.

Another concern with home-delivered meals is that most commercial vendors provide limited meal options that are appropriate for the ‘renal diet’, including meals low in sodium, phosphorus and potassium. The limited variety of meals may not be palatable for some patients, may not be culturally relevant, and even if they are, meal fatigue may become an issue over time. Some patients may also consume significant amounts of high-sodium foods in addition to home-delivered meals. However, Hummel *et al.* [29] reported 77% overall adherence with home-delivered meals and Troyer *et al.* [28] also reported increased adherence (reported as accordance) to the DASH diet. Another drawback is that providing meals may not help patients learn cooking skills that will help them sustain these dietary changes. An alternative approach would be to provide fresh produce, foods or meal kits in a manner similar to Goraya *et al.* [100] in individuals with earlier stages of CKD.

There are potential concerns that meal provision may discourage patients from taking behavioral responsibility, becoming increasingly reliant on another provider. However, provided home-delivered meals may be coupled with educational approaches to change short- or long-term behavior. Meal provision could demonstrate examples of healthy or desired dietary choices and lead to positive taste changes. These meals could also alleviate food insecurity and the regular consumption of processed or fast food [101] among patients on dialysis. Furthermore, the total calories and protein content of provided meals may be lower than recommended for HD patients. If so, these patients may simply require additional healthy snacks or oral nutrition supplements to meet energy and protein requirements, which is already common clinical practice. Finally, providing meals in this manner could have similar benefits for patients with earlier stages of CKD or on peritoneal dialysis, who often exhibit volume overload as well [102]. The reduction of sodium intake and volume-dependent hypertension in earlier stages of kidney disease could reduce cardiovascular risk, which contributes to the progression of CKD. By the time individuals reach end-stage kidney disease and dialysis, nearly 75% of patients present with left ventricular hypertrophy [103].

CONCLUSIONS

In summary, while the long-term efficacy of home-delivered meals in patients undergoing chronic HD needs to be evaluated, there are a number of potential benefits that make this an intriguing idea to explore. If dietary sodium can be effectively controlled, chronic volume overload may be effectively reduced and this may translate into improvements in cardiovascular-related outcomes. To date, many studies have failed to show that dietary education and counseling produce sustained changes in sodium intake in HD patients. This is not surprising, given the ubiquitous presence of sodium in our food supply and the plethora of barriers that HD patients face when trying to limit their sodium intake. Home-delivered, low-sodium meal delivery services may help HD patients overcome many of these barriers. Clinical trials, quality improvement programs and other studies need to investigate the efficacy of meal provision in HD to demonstrate this approach is a cost-effective and sustainable model to achieve sodium restriction. Importantly, low-sodium meal delivery may improve both clinical outcomes and patient quality of life, which should be welcomed by both healthcare providers and patients alike.

CONFLICT OF INTEREST STATEMENT

A.B. has received honoraria from Amgen and research grants from Keryx Pharmaceuticals for work unrelated to the present manuscript and is part of the AUGmeNt workgroup from the Academy of Nutrition and Dietetics. L.P. and K.W. declared no conflicts of interest.

REFERENCES

1. Agarwal R, Nissenson AR, Batlle D *et al*. Prevalence, treatment, and control of hypertension in chronic hemodialysis patients in the united states. *Am J Med* 2003; **115**: 291–297
2. Ok E, Asci G, Chazot C *et al*. Controversies and problems of volume control and hypertension in haemodialysis. *Lancet* 2016; **388**: 285–293
3. Antlanger M, Hecking M, Haidinger M *et al*. Fluid overload in hemodialysis patients: a cross-sectional study to determine its association with cardiac biomarkers and nutritional status. *BMC Nephrol* 2013; **14**: 266
4. Wabel P, Moissl U, Chamney P *et al*. Towards improved cardiovascular management: the necessity of combining blood pressure and fluid overload. *Nephrol Dial Transplant* 2008; **23**: 2965–2971
5. Ekinci C, Karabork M, Siriopol D *et al*. Effects of volume overload and current techniques for the assessment of fluid status in patients with renal disease. *Blood Purif* 2018; **46**: 34–47
6. Voroneanu L, Gavrilovici C, Covic A. Overhydration, underhydration, and total body sodium: a tricky "ménage a trois" in dialysis patients. *Semin Dial* 2018; **31**: 21–25
7. Wizemann V, Wabel P, Chamney P *et al*. The mortality risk of overhydration in haemodialysis patients. *Nephrol Dial Transplant* 2009; **24**: 1574–1579
8. Kalantar-Zadeh K, Regidor DL, Kovesdy CP *et al*. Fluid retention is associated with cardiovascular mortality in patients undergoing long-term hemodialysis. *Circulation* 2009; **119**: 671–679
9. Agarwal R. Hypervolemia is associated with increased mortality among hemodialysis patients. *Hypertension* 2010; **56**: 512–517
10. Chazot C, Wabel P, Chamney P *et al*. Importance of normohydration for the long-term survival of haemodialysis patients. *Nephrol Dial Transplant* 2012; **27**: 2404–2410
11. Georgianos PI, Agarwal R. Blood pressure control in conventional hemodialysis. *Semin Dial* 2018; **31**: 557–562
12. Wright JA, Cavanaugh KL. Dietary sodium in chronic kidney disease: a comprehensive approach. *Semin Dial* 2010; **23**: 415–421
13. Georgianos PI, Agarwal R. Pharmacotherapy of hypertension in chronic dialysis patients. *Clin J Am Soc Nephrol* 2016; **11**: 2062–2075
14. Hand RK, Steiber A, Burrowes J. Renal dietitians lack time and resources to follow the NKF KDOQI guidelines for frequency and method of diet assessment: results of a survey. *J Ren Nutr* 2013; **23**: 445–449
15. Scribner BH. Can antihypertensive medications control BP in haemodialysis patients: yes or no? *Nephrol Dial Transplant* 1999; **14**: 2599–2601.
16. Curtis JR, Eastwood JB, Smith EK *et al*. Maintenance haemodialysis. *Q J Med* 1969; **38**: 49–89
17. Comty C, Rottka H, Shaldon S. Blood pressure control in patients with end-stage renal failure treated by intermittent haemodialysis. *Proc Eur Dial Transplant Assoc* 1964; **1**: 209–213
18. Scribner BH. A personalized history of chronic hemodialysis. *Am J Kidney Dis* 1990; **16**: 511–519
19. Fishbane SA, Scribner BH. Blood pressure control in dialysis patients. *Semin Dial* 2002; **15**: 144–145
20. Charra B, Calemard E, Cuche M *et al*. Control of hypertension and prolonged survival on maintenance hemodialysis. *Nephron* 1983; **33**: 96–99
21. Ozkahya M, Ok E, Toz H *et al*. Long-term survival rates in haemodialysis patients treated with strict volume control. *Nephrol Dial Transplant* 2006; **21**: 3506–3513
22. Shaldon S. Dietary salt restriction and drug-free treatment of hypertension in ESRD patients: a largely abandoned therapy. *Nephrol Dial Transplant* 2002; **17**: 1163–1165
23. Miskulin DC, Gassman J, Schrader R *et al*. BP in dialysis: results of a pilot study. *J Am Soc Nephrol* 2018; **29**: 307–316
24. Agarwal R, Alborzi P, Satyan S *et al*. Dry-weight reduction in hypertensive hemodialysis patients (DRIP): a randomized, controlled trial. *Hypertension* 2009; **53**: 500–507
25. Thein H, Haloob I, Marshall MR. Associations of a facility level decrease in dialysate sodium concentration with blood pressure and interdialytic weight gain. *Nephrol Dial Transplant* 2007; **22**: 2630–2639
26. Charra B, Chazot C. The neglect of sodium restriction in dialysis patients: a short review. *Hemodial Int* 2003; **7**: 342–347
27. Bossola M, Pepe G, Vulpio C. The frustrating attempt to limit the interdialytic weight gain in patients on chronic hemodialysis: new insights into an old problem. *J Ren Nutr* 2018; **28**: 293–301
28. Troyer JL, Racine EF, Ngugi GW *et al*. The effect of home-delivered Dietary Approach to Stop Hypertension (DASH) meals on the diets of older adults with cardiovascular disease. *Am J Clin Nutr* 2010; **91**: 1204–1212
29. Hummel SL, Karmally W, Gillespie BW *et al*. Home-delivered meals postdischarge from heart failure hospitalization. *Circ Heart Fail* 2018; **11**: e004886

30. Kalogeropoulos A, Papadimitriou L, Georgiopoulou VV *et al*. Low- versus moderate-sodium diet in patients with recent hospitalization for heart failure. *Circ Heart Fail* 2020; **13**: e006389
31. Perez LM, Fang H-Y, Ashrafi S-A *et al*. Pilot study to reduce interdialytic weight gain through low-sodium home-delivered meals in hemodialysis patients. *Hemodial Int* 2021; **25**: 265–274
32. Kopp C, Linz P, Wachsmuth L *et al*. ^{23}Na magnetic resonance imaging of tissue sodium. *Hypertension* 2012; **59**: 167–172
33. Dahlmann A, Dörfelt K, Eicher F *et al*. Magnetic resonance-determined sodium removal from tissue stores in hemodialysis patients. *Kidney Int* 2015; **87**: 434–441
34. Kopp C, Linz P, Dahlmann A *et al*. ^{23}Na magnetic resonance imaging-determined tissue sodium in healthy subjects and hypertensive patients. *Hypertension* 2013; **61**: 635–640
35. Schneider MP, Raff U, Kopp C *et al*. Skin sodium concentration correlates with left ventricular hypertrophy in CKD. *J Am Soc Nephrol* 2017; **28**: 1867–1876
36. Biruete A, Jeong JH, Barnes JL *et al*. Modified nutritional recommendations to improve dietary patterns and outcomes in hemodialysis patients. *J Ren Nutr* 2017; **27**: 62–70
37. Weiner DE, Brunelli SM, Hunt A *et al*. Improving clinical outcomes among hemodialysis patients: a proposal for a “Volume First” approach from the chief medical officers of US dialysis providers. *Am J Kidney Dis* 2014; **64**: 685–695
38. Lindley EJ. Reducing sodium intake in hemodialysis patients. *Semin Dial* 2009; **22**: 260–263
39. Ikizler TA, Burrowes JD, Byham-Gray LD *et al*. KDOQI clinical practice guideline for nutrition in CKD: 2020 update. *Am J Kidney Dis* 2020; **76(3 Suppl 1)**: S1–S107
40. Kugler C, Vlaminck H, Haverich A *et al*. Nonadherence with diet and fluid restrictions among adults having hemodialysis. *J Nurs Scholarsh* 2005; **37**: 25–29
41. Ok E, Mees EJD. Unpleasant truths about salt restriction. *Semin Dial* 2010; **23**: 1–3
42. Tomson CRV. Advising dialysis patients to restrict fluid intake without restricting sodium intake is not based on evidence and is a waste of time. *Nephrol Dial Transplant* 2001; **16**: 1538–1542
43. Juraschek SP, Miller ER, Chang AR *et al*. Effects of sodium reduction on energy, metabolism, weight, thirst, and urine volume. *Hypertension* 2020; **75**: 723–729
44. Bots CP, Brand HS, Veerman ECI *et al*. Chewing gum and a saliva substitute alleviate thirst and xerostomia in patients on haemodialysis. *Nephrol Dial Transplant* 2005; **20**: 578–584
45. Kusaba T, Mori Y, Masami O *et al*. Sodium restriction improves the gustatory threshold for salty taste in patients with chronic kidney disease. *Kidney Int* 2009; **76**: 638–643
46. Kim TH, Kim YH, Bae NY *et al*. Salty taste thresholds and preference in patients with chronic kidney disease according to disease stage: a cross-sectional study. *Nutr Diet* 2018; **75**: 59–64
47. Bruzda-Zwiech A, Szczepańska J, Zwiech R. Xerostomia, thirst, sodium gradient and inter-dialytic weight gain in hemodialysis diabetic vs. non-diabetic patients. *Med Oral Patol Oral Cir Bucal* 2018; **23**: e406–e412.
48. Bots CP, Brand HS, Veerman ECI *et al*. Interdialytic weight gain in patients on hemodialysis is associated with dry mouth and thirst. *Kidney Int* 2004; **66**: 1662–1668
49. Clark-Cutaia MN, Ren D, Hoffman LA *et al*. Adherence to hemodialysis dietary sodium recommendations: influence of patient characteristics, self-efficacy, and perceived barriers. *J Ren Nutr* 2014; **24**: 92–99
50. Titze J, Dahlmann A, Lerchl K *et al*. Spooky sodium balance. *Kidney Int* 2014; **85**: 759–767
51. Wiig H, Luft FC, Titze JM. The interstitium conducts extrarenal storage of sodium and represents a third compartment essential for extracellular volume and blood pressure homeostasis. *Acta Physiol* 2018; **222**: e13006
52. Titze J. Sodium balance is not just a renal affair. *Curr Opin Nephrol Hypertens* 2014; **23**: 101–105
53. Anvari E, Mojazi Amiri H, Aristimuno P *et al*. Comprehensive and personalized care of the hemodialysis patient in Tassin, France: a model for the patient-centered medical home for subspecialty patients. *ISRN Nephrol* 2013; **2013**: 792732
54. Charra B, Calemard E, Ruffet M *et al*. Survival as an index of adequacy of dialysis. *Kidney Int* 1992; **41**: 1286–1291
55. Krautzig S, Janssen U, Koch KM *et al*. Dietary salt restriction and reduction of dialysate sodium to control hypertension in maintenance haemodialysis patients. *Nephrol Dial Transplant* 1998; **13**: 552–553
56. Ozkahya M, Toz H, Qzerkan F *et al*. Impact of volume control on left ventricular hypertrophy in dialysis patients. *J Nephrol* 2002; **15**: 655–660
57. Kayikcioglu M, Tumuklu M, Ozkahya M *et al*. The benefit of salt restriction in the treatment of end-stage renal disease by haemodialysis. *Nephrol Dial Transplant* 2009; **24**: 956–962
58. Ozkahya M, Töz H, Unsal A *et al*. Treatment of hypertension in dialysis patients by ultrafiltration: role of cardiac dilatation and time factor. *Am J Kidney Dis* 1999; **34**: 218–221
59. Ozkahya M, Ok E, Cirit M *et al*. Regression of left ventricular hypertrophy in haemodialysis patients by ultrafiltration and reduced salt intake without antihypertensive drugs. *Nephrol Dial Transplant* 1998; **13**: 1489–1493
60. Raimann JG, Williams C, Gupta S *et al*. FP648 Systematic reduction of interdialytic weight gain and post hemodialysis weight lowers systolic and dialstolic blood pressure: preliminary results of a quality improvement project. *Nephrol Dial Transplant* 2015; **30(Suppl 3)**: iii290
61. Perez LM, Burrows BT, Chan LE *et al*. Pilot feasibility study examining the effects of a comprehensive volume reduction protocol on hydration status and blood pressure in hemodialysis patients. *Hemodial Int* 2020; **24**: 414–422
62. Erdem Y, Arici M, Altun B *et al*. The relationship between hypertension and salt intake in Turkish population: SALTURK study. *Blood Press* 2010; **19**: 313–318
63. Penne EL, Levin NW, Kotanko P. Improving volume status by comprehensive dietary and dialytic sodium management in chronic hemodialysis patients. *Blood Purif* 2010; **30**: 71–78
64. Kimura G, Kojima S, Saito F *et al*. Quantitative estimation of dietary intake in patients on hemodialysis. *Int J Artif Organs* 1988; **11**: 161–168
65. Fine A, Fontaine B, Ma M. Commonly prescribed salt intake in continuous ambulatory peritoneal dialysis patients is too restrictive: results of a double-blind crossover study. *J Am Soc Nephrol* 1997; **8**: 1311–1314
66. Ramdeen G, Tzamaloukas AH, Malhotra D *et al*. Estimates of interdialytic sodium and water intake based on the balance principle: differences between nondiabetic and diabetic subjects on hemodialysis. *ASAIO J* 1998; **44**: 812–817
67. Maduell F, Navarro V. Dietary salt intake and blood pressure control in haemodialysis patients. *Nephrol Dial Transplant* 2000; **15**: 2063

68. Rigby-Mathews AJ, Scribner BH, Ahmad S. Control of interdialytic weight gain (IDWG) without water restriction in hemodialysis patients. *J Am Soc Nephrol* 1999; **10**: A1346
69. Rodrigues Telini LS, de Carvalho Beduschi G, Caramori JCT *et al*. Effect of dietary sodium restriction on body water, blood pressure, and inflammation in hemodialysis patients: a prospective randomized controlled study. *Int Urol Nephrol* 2014; **46(1)**: 91–97
70. Sevick MA, Piraino BM, St-Jules DE *et al*. No difference in average interdialytic weight gain observed in a randomized trial with a technology-supported behavioral intervention to reduce dietary sodium intake in adults undergoing maintenance hemodialysis in the United States: primary outcomes of the BalanceWise Study. *J Ren Nutr* 2016; **26**: 149–158
71. Sakai MSc A, Hamada H, Hara K *et al*. Nutritional counseling regulates interdialytic weight gain and blood pressure in outpatients receiving maintenance hemodialysis. *J Med Invest* 2017; **64**: 129–135
72. Clark S, Farrington K, Chilcot J. Nonadherence in dialysis patients: prevalence, measurement, outcome, and psychological determinants. *Semin Dial* 2014; **27**: 42–49
73. Clark-Cutaia MN, Sevick MA, Thurheimer-Cacciotti J *et al*. Perceived barriers to adherence to hemodialysis dietary recommendations. *Clin Nurs Res* 2019; **28**: 1009–1029
74. López-Gómez JM, Villaverde M, Jofre R *et al*. Interdialytic weight gain as a marker of blood pressure, nutrition, and survival in hemodialysis patients. *Kidney Int* 2005; **67**: S63–S68
75. Hecking M, Karaboyas A, Saran R *et al*. Dialysate sodium concentration and the association with interdialytic weight gain, hospitalization, and mortality. *Clin J Am Soc Nephrol* 2012; **7**: 92–100
76. Ipema KJR, Kuipers J, Westerhuis R *et al*. Causes and consequences of interdialytic weight gain. *Kidney Blood Press Res* 2016; **41**: 710–720
77. Wong MMY, McCullough KP, Bieber BA *et al*. Interdialytic weight gain: trends, predictors, and associated outcomes in the International Dialysis Outcomes and Practice Patterns Study (DOPPS). *Am J Kidney Dis* 2017; **69**: 367–379
78. St-Jules DE, Woolf K, Lou Pompeii M *et al*. Exploring problems in following the hemodialysis diet and their relation to energy and nutrient intakes: the BalanceWise Study. *J Ren Nutr* 2016; **26**: 118–124
79. Crews DC, Kuczmarski MF, Grubbs V *et al*. Effect of food insecurity on chronic kidney disease in lower-income americans. *Am J Nephrol* 2014; **39**: 27–35
80. Dageforde LA, Cavanaugh KL. Health literacy: emerging evidence and applications in kidney disease care. *Adv Chronic Kidney Dis* 2013; **20**: 311–319
81. Perez L. Dietary interventions and strategies to reduce sodium consumption and volume overload in hemodialysis patients. PhD dissertation, University of Illinois at Urbana-Champaign. https://www.ideals.illinois.edu/handle/2142/110482 (26 January 26 2022, date last accessed)
82. Betz M, Steenes A, Peterson L *et al*. Knowledge does not correspond to adherence of renal diet restrictions in patients with chronic kidney disease stage 3–5. *J Ren Nutr* 2021; **31**: 351–360
83. Burton JO, Jefferies HJ, Selby NM *et al*. Hemodialysis-induced cardiac injury: determinants and associated outcomes. *Clin J Am Soc Nephrol* 2009; **4**: 914–920
84. Melton A. Home-delivered meal options for chronic kidney disease patients. *J Ren Nutr* 2012; **22**: e47–e50
85. Su G, Qin X, Yang C *et al*. Fiber intake and health in people with chronic kidney disease. *Clin Kidney J* 2022; **15**: 213–225
86. Biruete A, Shin A, Kistler BM *et al*. Feeling gutted in chronic kidney disease (CKD): gastrointestinal disorders and therapies to improve gastrointestinal health in individuals CKD, including those undergoing dialysis. *Semin Dial* 2021; doi:10.1111/SDI.13030
87. Carrero JJ, González-Ortiz A, Avesani CM *et al*. Plant-based diets to manage the risks and complications of chronic kidney disease. *Nat Rev Nephrol* 2020; **16**: 525–542
88. Tuso P, Beattie S. Nutrition reconciliation and nutrition prophylaxis: toward total health. *Perm J* 2015; **19**: 80–86
89. PurFoods. Mom's meals self-pay meal costs. https://www.momsmeals.com/self-pay/ (30 June 2020, date last accessed)
90. Mohr PE, Neumann PJ, Franco SJ *et al*. The case for daily dialysis: its impact on costs and quality of life. *Am J Kidney Dis* 2001; **37**: 777–789
91. Lee H, Manns B, Taub K *et al*. Cost analysis of ongoing care of patients with end-stage renal disease: the impact of dialysis modality and dialysis access. *Am J Kidney Dis* 2002; **40**: 611–622
92. Just PM, Riella MC, Tschosik EA *et al*. Economic evaluations of dialysis treatment modalities. *Health Policy* 2008; **86**: 163–180
93. St. Peter WL, Wazny LD, Weinhandl ED. Phosphate-binder use in US dialysis patients: prevalence, costs, evidence, and policies. *Am J Kidney Dis* 2018; **71**: 246–253
94. Leaf DE, Cheng XS, Sanders JL *et al*. An electronic alert to decrease kayexalate ordering. *Ren Fail* 2016; **38**: 1752
95. Little DJ, Nee R, Abbott KC *et al*. Cost-utility analysis of sodium polystyrene sulfonate vs. potential alternatives for chronic hyperkalemia. *Clin Nephrol* 2014; **81**: 259–268
96. Desai NR, Reed P, Alvarez PJ *et al*. The economic implications of hyperkalemia in a Medicaid managed care population. *Am Health Drug Benefits* 2019; **12**: 352–361
97. Suresh A, Robinson L, Milliron B-J *et al*. Approaches to obesity management in dialysis settings: renal dietitian perspectives. *J Ren Nutr* 2020; **30**: 561–566
98. Forwood SE, Ahern AL, Hollands GJ *et al*. Priming healthy eating. You can't prime all the people all of the time. *Appetite* 2015; **89**: 93–102
99. Bertino M, Beauchamp GK, Engelman K. Long-term reduction in dietary sodium alters the taste of salt. *Am J Clin Nutr* 1982; **36**: 1134–1144
100. Goraya N, Munoz-Maldonado Y, Simoni J *et al*. Fruit and vegetable treatment of chronic kidney disease-related metabolic acidosis reduces cardiovascular risk better than sodium bicarbonate. *Am J Nephrol* 2019; **49**: 438–448
101. Butt S, Leon JB, David CL *et al*. The prevalence and nutritional implications of fast food consumption among patients receiving hemodialysis. *J Ren Nutr* 2007; **17**: 264–268
102. Kim YL, Biesen W Van. Fluid overload in peritoneal dialysis patients. *Semin Nephrol* 2017; **37**: 43–53
103. McCullough PA, Chan CT, Weinhandl ED *et al*. Intensive hemodialysis, left ventricular hypertrophy, and cardiovascular disease. *Am J Kidney Dis* 2016; **68(5 Suppl 1)**: S5–S14