Medical nutrition therapy using plant-focused low-protein meal plans for management of chronic kidney disease in diabetes

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Purpose of review
Nearly half of all Americans with chronic kidney disease (CKD) also have type-2-diabetes (T2D). Whereas traditional and emerging pharmacotherapies are increasingly frequently used for the management of CKD in diabetes (CKD/DM), the role of integrated or multimodal interventions including the potentially synergistic and additive effect of diet and lifestyle modifications in addition to pharmacotherapy has not been well examined, in sharp contrast to the well-known integrated approaches to heart disease.

Recent findings
Low-carbohydrate low-fat diets are often recommended in T2D, whereas low-protein diets (LPD) are recommended by guidelines for nondiabetic CKD with increasing emphasis on plant-based protein sources. High-protein diets with greater animal protein lead to glomerular hyperfiltration, especially in patients with T2D, and faster decline in renal function. Guidelines provide differing recommendations regarding the amount (low vs high) and source (plant vs animal) of dietary protein intake (DPI) in CKD/DM. Some such as KDIGO recommend 0.8 g/kg/day based on insufficient evidence for DPI restriction in CKD/DM, whereas KDOQI and ISRNM recommend a DPI of 0.6 to <0.8 g/kg/day. A patient-centered plant-focused LPD for the nutritional management of CKD/DM (PLAFOND), a type of PLADO diet comprising DPI of 0.6 to <0.8 g/kg/day with >50% plant-based sources, high dietary fiber, low glycemic index, and 25–35 Cal/kg/day energy, can be implemented by renal dietitians under Medical Nutrition Therapy.

Summary
Potential risks vs benefits of high vs low protein intake in CKD/DM is unknown, for which expert recommendations remain opinion based. Randomized controlled studies are needed to examine safety, acceptability and efficacy of PLAFOND.

Keywords
diabetic kidney disease, dietary protein intake, glomerular hyperfiltration, meal plans, medical nutrition therapy, plant-focused diet

INTRODUCTION

Chronic kidney disease (CKD) affects 15% of the US adults, and increases cardiovascular (CV) morbidity and mortality [1,2,3▪▪]. CKD is irreversible and can progress to 'kidney failure' requiring dialysis therapy or transplantation [4,5▪▪]. Each year, 130,000 Americans transition to dialysis, which is costly and associated with reduced health-related quality of life (QOL) and high mortality with >20% dying within the first year of dialysis initiation [1,6–11]. Most patients with CKD do not progress to kidney failure due to competing risks of CV morbidity and mortality which increases as glomerular filtration rate (GFR) declines [12]. Hence, slowing CKD progression and preventing or delaying dialysis can have major implications on CKD outcomes.

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KEY POINTS

- A subtype of the PLADO diet for nutritional management of patients with CKD/DM is PLAFOND, a patient-centered plant-focused LPD, comprising DPI of 0.6 to <0.8 g/kg/day with >50% plant-based sources, high dietary fiber, low glycemic index, and 25–35 Cal/kg/day energy.
- Renal dietitians play an instrumental role in implementing MNT in patients with CKD/DM using PLAFOND meal plans, which is different from the traditional low-potassium 'renal diet'.
- MNT models using PLAFOND or other PLADO diets stand in sharp contradistinction to the current CKD nutritional management systems whereby the renal dietitians' focus of work is in the dialysis clinic, whereas patients at-risk of kidney failure have little or no nutritional support.

CKD affects 30–40% of all persons with diabetes mellitus [1,2]. *CKD in Diabetes* (*CKD/DM*), also known as *Diabetic Kidney Disease* or DKD, is associated with multimorbid conditions including micro- and macro-angiopathies leading to poor clinical outcomes [13,14]. Without effective management, CKD/DM almost invariably progresses fast to kidney failure requiring dialysis or transplantation [3▪▪]. A third to half of all 130,000 patients with CKD who transition to kidney failure therapies each year also have T2D [1,2,15▪▪,16]. Patients with type 2 diabetes (T2D) exhibit more rapid CKD progression than nondiabetic CKD [15▪▪,17]. Using national veteran data, a faster eGFR decline is associated with higher postdialysis mortality [18,19], whereas a kidney profile of slower progression slope in the prelude period prior to transition to dialysis and a later dialysis start are associated with more favorable postdialysis outcomes [19]. Hence, diet and lifestyle modification trials to examine a more conservative and delayed transition are warranted.

INTEGRATED APPROACHES AND DIETARY EQUIPOISE IN CHRONIC KIDNEY DISEASE IN DIABETES

Whereas traditional and emerging pharmacotherapies including angiotensin pathway modulators, also known as renin angiotensin aldosterone system (RAAS) blockade, and sodium-glucose transport protein 2 (SGLT2) inhibitors are increasingly used in CKD/DM, the role of *integrated* or *multimodal* interventions including the potentially synergistic and additive effect of diet and lifestyle modifications in addition to pharmacotherapy has not been well examined in this population [3▪▪,5▪▪]. This is in sharp contrast to the well-known integrated approaches to heart disease where pharmacotherapy including use of statins is almost invariably combined with diet and lifestyle adjustments [20–23].

Low-carbohydrate low-fat diets are often recommended in T2D whereas low-protein diets (LPD) are sometimes considered for nondiabetic CKD, with increasing interest in plant-based protein sources [3▪▪,24,25▪▪,26–29]. Our and others' research have shown that high-protein diets (HPD) with greater animal protein content lead to glomerular hyperfiltration and faster decline in renal function [25▪▪,30▪▪,31]. However, there is major concern about the potential risks and harms of LPD specifically in patients with T2D, for which there are only opinion-based recommendations in recent KDOQI guidelines, given that these patients are already restricting carbohydrates and fats and overall caloric intake, so that LPD may lead to protein-energy wasting (PEW) and frailty as well as dysglycemia. However, *patients with CKD/DM are ironically the population who may most benefit from LPD* because they have 1) even greater glomerular hyperfiltration [32], and 2) more rapid CKD progression than nondiabetic CKD [15▪▪,17]. Major clinical practice guidelines (ADA [33], KDIGO [15▪▪], KDOQI [34], ISRNM [35]) have differing recommendations regarding dietary protein intake (DPI) and plant vs animal-based protein in CKD/DM; whereas ADA and KDIGO advise against a lower DPI < 0.8 g/kg/day given insufficient evidence for restricting DPI in CKD/DM [15▪▪,33], KDOQI and ISRNM guidelines [34,35] recommend 0.6 to <0.8 g/kg/day based on expert opinion. Hence, high-quality diet intervention studies in CKD/DM are urgently needed given that prior LPD trials in CKD such as the 1994 *MDRD study* [36] excluded adults with diabetes who were receiving insulins (so that only 3 percentage of the participants had noninsulin-dependent diabetes) and did not examine plant-dominant foods widely recommended in contemporary culture [36].

HIGH PROTEIN DIETS MAY BE HARMFUL IN CHRONIC KIDNEY DISEASE IN DIABETES

The *Recommended Dietary Allowance* (*RDA*) of protein is 0.8 g/kg/day, whereas on average, Americans consume much higher amounts of protein (>1.2 g/kg/day) [37]. Evidence suggests that high DPI, by way of causing increased intraglomerular pressure with resultant glomerular hyperfiltration, may adversely affect kidney health over time across populations with or at-risk for CKD [25▪▪,38]. To substantiate the effect of high DPI on renal physiology, Tuttle *et al.*

showed that, in human volunteers amino acid infusion led to worse glomerular hyperfiltration in DM than non-DM [32]. Additionally, Kontessis *et al.* showed that independently of quantity of DPI plant-based protein had salutary renal hemodynamic effects compared to animal protein in persons without and with DM [31,39]. However, in secular practice, higher DPI is recommended to combat obesity [40,41], which is also promoted among US military servicemen and Veterans [42]. Given that T2D affects nearly one-quarter of Veterans, keto-diets high in protein and fat are gaining popularity in the Veterans Affairs (VA) healthcare system [43], whereas 'high biologic value' (HBV) protein as in animal protein may be associated with worse renal outcomes [44].

LPD, defined as DPI < 0.8 g/kg/day, has consistently been shown to lower intraglomerular pressure, and this may preserve long-term kidney function as corroborated in both animal models and in human studies of CKD, including several meta-analyses by our team and others [45–49]. Although our research findings support a DPI of 0.6–0.8 g/kg/day, Metzger *et al.* [50] showed that a DPI < 0.6 g/kg/day may result in even slower CKD progression; however, a DPI 0.6 to <0.8 g/kg/day, is considered the most pragmatic and safest target when used without amino-acid or keto-acid supplementation. The scientific premise for these DPI targets has been presented in a critical review of 16 LPD trials as discussed in the Appendix of *2017 New England Journal of Medicine* (*NEJM*) [24] review paper on LPDs for CKD. In a parallel review [25▪▪] and meta-analyses of these studies [48], a LPD of < 0.8 vs >0.8 g/kg/day was associated with a lower risk of kidney failure, azotemia, acidemia, hyperphosphatemia, and mortality. Safety and adherence to LPD was equivalent to a normal protein diet, and there was no malnutrition or PEW [48]. However, while most studies suggest that LPD ameliorates CKD progression, others have shown mixed findings [29,51], including the primary analyses of the *MDRD* Study that included only 3% of participants with CKD/DM and none were on insulin [36]. *Most trials except for MDRD were small and focused on surrogate endpoints*. Moreover, their dietary interventions were *labor-intensive*, *not patient-centered*, and *not aligned with contemporary culture* in consuming more plant-based dietary sources [38]. In part due to MDRD's negative findings and the impractical aspects of prior outdated dietary regimens, LPD's have not been widely utilized as a reno-protective intervention in most CKD patients. Thus, there is an urgent need for well-designed studies that apply LPD as a pragmatic, patient-centered, and sustainable intervention.

CAN DIET ENFORCE THE EFFECT OF PHARMACOTHERAPY IN CHRONIC KIDNEY DISEASE IN DIABETES?

Synergistically additive effect of LPD on RAAS blockade has been reported consistently in CKD [52,53]. Whereas a recent secondary analysis of several relatively small-sized SGLT2 inhibitors trials suggested that HPD did not offset the benefits of SGLT2 inhibition [54], in the DELIGHT trial, dapagliflozin vs placebo reduced urinary albumin to creatinine ratio by 21% in the high vs 28% in the low-protein group, suggesting 39% more effect of SGLT2 inhibitor if combined with lower protein intake. Interaction p-value was not significant likely because of limited sample size. Interestingly, the IMPROVE trial in the same analyses showed a very similar trend, in that there was a 38% more effect under restricted protein intake added to the effect of dapagliflozin as compared to the pharmacotherapy alone or in combination with higher DPI [55]. Hence, it may be true that LPD could offer additional synergistic benefits to patients undergoing flozination [56]. These data could be interpreted as a signal for *biologically plausible* trends in support of investigating LPD in addition to pharmacotherapy in CKD/DM [55].

The July 2019 US President's Executive Order seeks to reduce the number of Americans developing kidney failure by 25% by 2030 through improved efforts to prevent, detect, and slow the progression of CKD. This timely order underscores the importance of preventive CKD measures and reiterates the critical, underappreciated role of dietary interventions in optimizing kidney health [57]. These efforts are based on the scientific premise that feasible dietary interventions should be tested in CKD/DM, the leading cause of kidney failure epidemic in the US, and if effective, prioritized as the cornerstone of nonpharmacologic treatment in slowing CKD/DM progression and avoiding or delaying dialysis [26].

The typical American diet contains 15–25% protein with only less than 1/3 of that from plant-based sources [58]. Prior studies suggest that animal-based protein is harmful to kidney health, whereas a plant-dominant diet is protective and may slow CKD progression [59–62]. We highlight six key studies supporting these findings: (1) Kontessis *et al.* [31] examined volunteers fed for 3 weeks, a vegetable ($N = 10$), an animal ($N = 10$), or an animal protein diet supplemented with fiber ($N = 7$), all with the same amount of total protein; animal-based protein diets increased GFR more than similar amounts of plant-based proteins. Higher glomerular hyper-filtration was observed in those eating more meat and less vegetable-derived proteins [31]. (2) Lin *et al.* [63] examined

Table 1. Benefits and challenges of PLAFOND low protein diet with >50% plant sources of protein and high fiber content for patents with CKD and diabetes (CKD/DM), also known as DKD

Potential Advantages of PLAFOND	Putative Disadvantages of PLAFOND
Lowering acid-load given higher alkaline content	Risk of protein-energy wasting and malnutrition
Improving glomerular hyperfiltration by lowering intraglomerular pressure	Risk of obesity and/or undermining obesity management
Synergistic effect with RAAS blockade & SGLT2 inhibitors	Sarcopenia from inadequate essential amino acids
Reducing production of uremic metabolites and delaying or prevenitng dialysis initiation	Risk of hypo- and hyperglycemia
Preventing cardiovascular disease burden from high meat intake	Risk of hyperkalemia from high potassium load
Less absorbable phosphorus leading to lower phosphorus burden	Gastrointestinal symptoms due to high fiber content
Less interstitial fibrosis from lower TMAO	Low palatability and adherence
High dietary fiber enhancing GI motility	Inadequate dairy product, egg, and fish intake if vegan dieting is pursued
Favorable changes in microbiome	
Lowering inflammation and oxidative stress	

CKD, chronic kidney disease; CKD/DM, CKD in diabetes; PLAFOND, plant-focused low-protein nutrition for CKD in diabetes.

data of 3,348 women participating in the Nurses' Health Study and found that the highest quartile of meat intake was associated with higher risk of microalbuminuria, and so was animal fat (odds ratio 1.72, 95% CI: 1.12–2.64) and two or more servings of red meat per week (OR: 1.51, 95% CI: 1.01–2.26). (3) Kim *et al.* [64]. showed that in 14,686 US middle-aged adults, higher adherence to plant-based diets was associated with favorable kidney outcomes. (4) Haring *et al.* [65] showed that red and processed meat were associated with higher CKD risk, whereas nuts, low-fat dairy products, and legumes were protective against the development of CKD. (5) Chen *et al.* [66] showed lower mortality in CKD under diet with a higher plant source. (6) In the study by Naraski *et al.* [44] in 27,604 NHANES participants (1999–2010) a higher DPI and greater HBV consumption as in animal protein were associated with higher mortality in CKD (eGFR < 60 ml/min/1.73m^2) in contract to those with normal kidney function.

ADDITIONAL BENEFITS OF A PLANT-FOCUSED MEAL PLANS

A plant-focused LPD for nutritional management of CKD/DM, hereby abbreviated to 'PLAFOND', comprised of DPI of 0.6 to <0.8 g/kg/day with >50% plant-based sources in the intervention group, is consistent with the US RDA of DPI of 0.8 g/kg/day, which has a high safety margin, given that the lowest DPI requirement to avoid catabolic changes is 0.45–0.5 g/kg/day based on established metabolic studies [26]. It has been suggested that ≥50% of DPI should be from high biologically value or 'HBV' sources with high gastrointestinal absorbability of essential amino acids [67]. However, other metrics provide higher *protein quality* scores for plant-based sources [68]. Hence, PLAFOND is a type of 'plant dominant LPD' also known as PLADO diet [25▪▪] with lower glycemic index compared to other PLADO diet categories. There are multiple pathways by which LPD with >50% plants ameliorates CKD progression, in addition to reducing glomerular hyperfiltration and intra-glomerular pressure, as also shown in Table 1: [51] (1) reduction in nitrogenous compounds; [48] (2) synergism with RAAS and SGLT2 inhibitors; [52] (3) attenuation of metabolites linked with CKD and CV disease including via trimethylamine (TMA) and TMA N-oxide (TMAO) implicated in atherosclerosis, renal fibrosis axis [69], and CV disease and mortality; [70] (4) decreased acid load from plant-dominant diets; [71] (5) reduced phosphorus burden given less bioavailable phosphorus in plant-based protein and less added phosphorus-based preservatives that are typically used for meat processing; [60,72–74] (6) favorable modulation of advanced glycation end products by higher dietary fiber [75,76] and enhancing GI motility with lower likelihood of constipation, a likely contributor to hyperkalemia; [77,78▪▪] (7) favorable effects on potassium metabolism given lower likelihood of potassium-based additives that are often in meat products; [79,80] (8) anti-inflammatory and antioxidant effects from higher intake of natural anti-inflammatory and antioxidant ingredients including carotenoids, tocopherols, and ascorbic acid; [81,82] (9) favorable impact on the gut microbiome [83] leading to lower uremic toxin generation.

SAFETY AND ADEQUACY OF PLAFOND MEAL PLANS

Potential challenges of LPD including PLAFOND meal plans are listed in Table 1 and include the following: *(1) Risk of PEW, malnutrition, and muscle wasting:* As discussed above and based on the US recommended RDA for safe DPI ranges, it is highly unlikely that our targeted PLAFOND with DPI 0.6 to <0.8 g/kg/day will engender PEW in clinically stable individuals. No PEW was reported in 16 LPD trials cited above [26,48] including the MDRD study [26], although PEW per se is a risk of poor CKD outcomes including faster CKD progression [84]. The co-PI's, Drs. Kalantar and Rhee, have an extensive track record of research and clinical involvement in the management of PEW in CKD [85–87,88▪▪]. As stated in our study protocol, in CKD patients who develop signs of PEW or acute kidney injury (AKI), higher DPI targets will be temporarily used until PEW or AKI is resolved. *(2) Risk of obesity and hyperglycemia:* LPD therapy in CKD has not been shown to be associated with such risks, and indeed LPD with vegan diet has salutary effects on insulin resistance and glycemic index [29,89]. *(3) Risk of hyperkalemia:* We are not aware of scientific evidence to support the cultural dogma that restricting fruits and vegetables prevents hypekalemia [90]. Dietary K does *not* correlate closely with serum potassium variability in CKD [91,92]. Indeed, a high-fiber diet enhances bowel motility and likely prevents higher potassium absorption, and alkalization with plant-based dietary sources also lowers hyperkalemia risk [93–97]. Moreover, newly available potassium-binders, which were not FDA-approved during the era of prior LPD trials, may be used in our pragmatic RCT at the discretion of clinicians as described in study protocol [98]. *(4) Diet palatability and adherence:* Based on our extensive hands-on experience in implementing patient-centered LPD clinics for hundreds of CKD patients in both university settings and the VA system in collaboration with renal dietitians [67], and given our expertise in diet adherence research [67,99], we opine that our suggested PLAFOND diet with DPI of 0.6 to <0.8 g/kg/day and ≥50% plant-based proteins sources will be well accepted and sustainable among persons with CKD/DM [67]. Patients should have the opportunity to choose the contribution of plant-based protein sources and these strata along with palatability, appetite [100], and adherence should be closely monitored.

PLAFOND MEAL PLANS AND PATIENT CENTEREDNESS

The diet in the PLAFOND consists of a LPD amounting to 0.6 to <0.8 g/kg/day with at least 50% of the protein from plant-based sources [25▪▪] (Table 2). The LPD regimen should be patient-centric and flexible with respect to the targeted dietary goals and is constructed based on the preferences of the patients with the renal dietitian working with patients and their care-partners to that end (see below under Meal Plans), as opposed to strict dietary regimens under the so-called 'renal diet'. The prescribed energy intake is in the range of 25–35 Cal/kg/day [25▪▪]. The PLAFOND diet does NOT adhere to any of the strict vegan, vegetarian or pescatarian diets [51]. Patients under the PLAFOND therapy will choose the proportion of plant-based protein within two major categories of 50 to <75% (PLAFOND-1) or >75% (PLAFOND-2) as shown in Table 2 and also

Table 2. Comparing the PLAFOND meal plans based on low protein high fiber meal plans with >50% plant-based protein sources (including PLAFOND level 1 with plant-based protein sources of 50–75% and level 2 with >75% plant sources) vs standard *American Diabetes Association* (ADA) diet and the so-called 'renal diet', based on 2,400 Cal/day in an 80-kg person

	Standard ADA diet	Renal Diet	PLAFOND Level 1	PLAFOND Level 2[b]
Proportion of plant-based protein	25–35%	<25%	50 to <75%	>75%
Total protein per kg IBW per day	0.8–1.4	0.8–1.4	0.6 to <0.8	0.6 to <0.8
Total protein intake, g/day	96–112 g	96–112 g	48–64 g	48–64 g
Proportion of energy from protein	16–19%	>19%	8–11%	8–11%
Total plant-based protein, g/day	24–34 g/d	<24 g/d	24–48 g/d	36–64 g/d
Total animal-based protein, g/day	68–83	>83	12–32 g/d	<15 g/d
Sodium intake target, g/day[a]	<2.3	<2.3 (<1.7[a])	<4 (<3[a])	<4 (<3[a])
Potassium intake target, g/day	3–5 (RDA:4.7)	Usually <2	RDA: 4.7	RDA: 4.7

PLAFOND, plant-focused low-protein nutrition for CKD in diabetes.
[a]Lower sodium target will be pursued if there is edema or uncontrolled hypertension.
[b]Vegan diet is the extreme type of Level II PLAFOND.

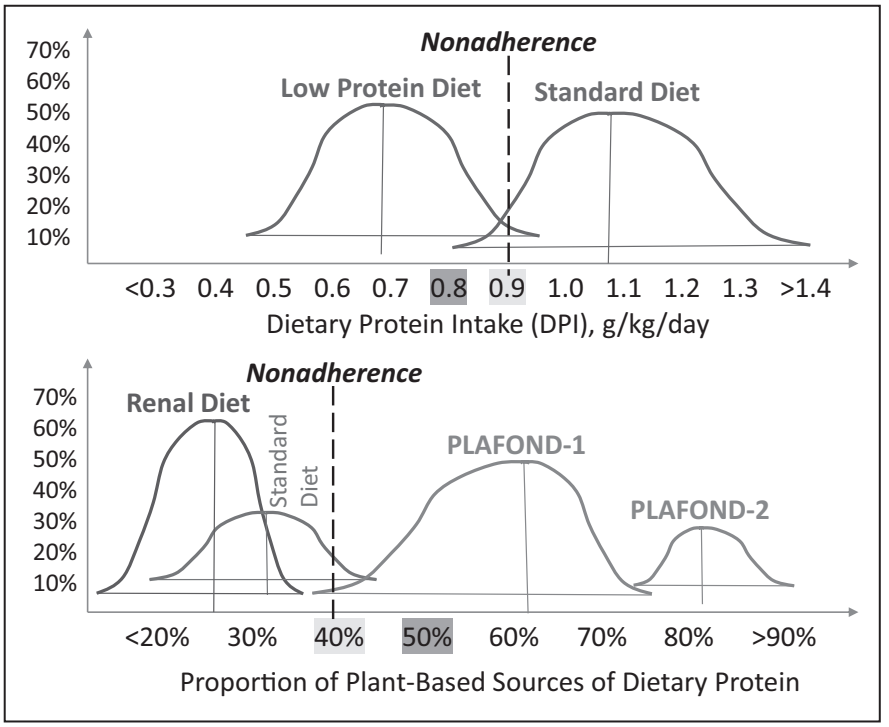

FIGURE 1. Overview of the plant-focused low-protein nutrition for CKD in diabetes (PLAFOND) for nutritional management of CKD/DM, based on a total dietary intake of 0.6 to <0.8 g/kg/day with >50% plant-based sources, preferentially unprocessed foods, relatively low dietary sodium intake < 3 g/day (but the patient can target to avoid >4 g/day if no edema with well controlled hypertension), higher dietary fiber of at least 25–30 g/day, and adequate dietary energy intake of 25–35 Cal/kg/day. The proportion of protein from plant-based sources under PLAFOND level 1 is 50–75% and under PLAFOND-2 is >75%. CKD, chronic kidney disease; CKD/DM, CKD in diabetes.

have the discretion of deciding upon the nonplant-based portion of the protein *ad lib*. Based on our experience in running LPD clinics for dietary management of CKD, most (2/3 of) CKD patients adhere to 50–75% plant-based sources, whereas 1/3 choose to target >75% or strict vegan diets.

It is important to note that the widely practiced low-potassium diet, also known as 'renal diet', further restricts the proportion of plant-based diet to < 25% resulting in preponderance of animal protein as the main source of CKD diet as widely practiced [78▪▪,98,101], which will likely accelerate CKD progression and worsen CV risk [45,51,102]. In patient-centered CKD management practice, strict dietary prescription should not be pursued, as such prescribed meal plans could limit the original goals of patient-centeredness in addition to ethical concerns with recommending strict animal proteins to patients with CKD.

Data on plant-based proportion of diet should be monitored closely both continuously and across incremental/discrete categories, i.e., (1) 50–75% (PLAFOND-1), (2) >75% (PLAFOND-2), (3) 25 to <50% (including nonadherent PLAFOND participants), and (4) <25% (most control patients under a low potassium 'renal diet', see Fig. 1. A set of predetermined meal plans within the different main categories should be created for all centers engaged in nutritional management of CKD and DKD, similar to the ones detailed in the 2017 *NEJM* paper's online appendix [24]. Dietary compliance and adjusting the meal plans for individual preferences is an important part of the medical nutrition therapy (MNT) by dietitians (see below).

MEDICAL NUTRITION THERAPY OF PLAFOND BY RENAL DIETITIANS

To implement PLAFOND meal plans effectively, renal dietitians with expertise in dietary management of NDD-CKD should coordinate and communicate with the clinic nephrologists. The dietitians should perform the bulk of dietary education and evaluations along with nutritional and body composition testing including (1) Dietary education for both PLAFOND and standard renal diets according to patient's preferences, (2) Dietary assessment using a 3-day diet diary with interview, (3) Body anthropometry including triceps and biceps skinfolds [103] and mid-arm circumference as an

optional assessment especially if there is higher risk of PEW [104], or obesity including body fat estimation (4) the Malnutrition-Inflammation Score (MIS, also known as Kalantar Score) [105–110] which included the Subjective Global Assessment embedded in it [111], (5) For the assessment of frailty and as indicated: *Short Physical Performance Battery* (SPPB) [112,113] and the *Fried Frailty Index;* [114–116] or its telehealth versions [117,118].

Adherence to the prescribed PLAFOND diet should be evaluated by comparing the LPD goal (0.6 to <0.8 g/kg/day range) to the 3-day diet assessment with dietary interview [119] and calculated DPI using 24-h collections [24,119]. Complementary education of the patient and care-partner(s) will be provided both during the face-to-face or telehealth visits and via monthly to quarterly phone calls as needed. The dietary educations along with the above evaluations will take one to two hours of the dietitian's time during each visit. Consistent with the pragmatic nature of the PLAFOND MNT, the dietitian visits can coincide with the nephrology clinic visits, in that the CKD dietitian is based in the ambulatory nephrology space in a separate room, and interviews and evaluates patients efficiently in synchrony with the routine clinic flow. Since April 2020 under the COVID-19 pandemic, some of the CKD nutrition centers have successfully adapted to telehealth and telenutrition [120▪].

Based on our experience in our CKD clinics, the standard vs low protein is 1.22 ± 0.24 vs 0.68 ± 0.27 g/kg/day, respectively, and the proportion of plant-based source of protein across four categories of Table 2 are 23% (low-potassium renal diet), 29% (nonlow-potassium diet), 63% (PLAFOND-1) and 84% (PLAFOND-2). Based on these data, for our proposed study we define nonadherence with either diet as DPI crossing 0.9 g/kg/day and/or 40% plant proportion of protein (see Fig. 1). Upon identifying nonadherence, the dietitian and nephrologist should evaluate the patient data and communicate with the patient to identify, address, and resolve barriers and challenges to adherence.

MNT using the PLAFOND does not interfere with any other aspects of the CKD or diabetes patient care including prescribed medications for CKD and T2D management. However, clinical follow-ups should occur throughout the MNT period [121] and adjustments are to be made as needed, including under safety surveillance strategies, e.g., serum potassium or glycemic deviations. Whereas the default strategy is based on no interference with other medical care, providers should communicate the need of changing ancillary interventions, (e.g., adjusting antidiabetic medication doses after weight loss or hypoglycemia) with the patient's primary care physician or the appropriate specialist, as indicated by the specific medical issue. Indeed, it is expected that dietary protein modifications will have a synergistic effect on pharmacotherapy [52,55].

CONCLUSION

PLAFOND is a patient-centered plant-focused LPD for nutritional management of CKD/DM, a type of PLADO diet comprising DPI of 0.6 to <0.8 g/kg/day with >50% plant-based sources, high dietary fiber, low glycemic index, and 25–35 Cal/kg/day energy, can be implemented by renal dietitians under MNT. Empowering renal dietitians to implement MNT-based PLAFOND meal plans for management of CKD/DM highlights the potential role of diet and nutrition in CKD/DM management beyond the traditional low-potassium low-sodium diet [121]. Implementation of MNT with PLAFOND could have major and positive impact on millions of Americans with CKD/DM, who would benefit from patient-centered dietary regimens. By *challenging traditional dialysis-centered and low-potassium diet paradigms*, this patient-centered MNT will also have significant clinical and public health implications among millions of Americans with T2D who are at-risk for or have existing CKD. Centers that implement PLAFOND therapy and collect data can contribute critical data about the feasibility and safety of patient-tailored LPD regimens and will challenge the prevailing dialysis-centered paradigm. Patient-centered MNT approaches are also aligned with the July 2019 US Presidential Executive Order's restructuring of the CKD program by preemptively involving patients and dietitians in earlier phases of CKD care rather than dialysis preparation [57]. This model stands in sharp contrast to the current payment system whereby the renal dietitians' focus of work is in the dialysis units, whereas patients at-risk of kidney failure have little or no nutritional support.

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Conflicts of interest

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Papers of particular interest, published within the annual period of review, have been highlighted as:

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This is a comtemporary review of CKD manageement with comprehensive data on both phrmacologic and nonpharmacologic options.

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