important standard of practice to lower elevated phosphate levels, but previous 2009 recommendation 4.1.7 (now 4.1.8) on limiting dietary phosphate intake was considered vague, especially with regard to new evidence on different phosphate and phosphoprotein sources. Within this guideline update, predefined criteria on study duration and cohort size prohibited inclusion of some study reports for full evidence review. Nevertheless, the Work Group felt that some of these reports presented safety signals demanding a brief discussion.

As summarized in Supplementary Tables S25–S30, only 2 studies on this topic in dialysis patients fulfilled the evidence review criteria.[104,105] Both studies investigated the impact of intensified versus routine dietary counseling on serum phosphate levels after a follow-up of 6 months. In both studies, the intensified counseling groups more successfully reached the laboratory targets; however, no hard endpoints were documented. Accordingly, the quality of evidence for outcome was rated as very low. Similarly, a recent Cochrane review concluded that there is low-quality evidence that dietary interventions positively affect CKD-MBD biomarkers.[106]

The daily phosphate intake for a typical American diet varies with age and gender. A majority of young to middle-aged men take in more than 1600 mg/d, whereas women in the same age groups take in about 1000 mg/d.[107] On a global scale, there are quite significant differences in diet compositions to be considered. Estimates of dietary phosphate from food composition tables likely underestimate the phosphate content because they may mostly reflect the "natural" phosphate content of foods that are highest (e.g., dairy products, meats, poultry, fish, and grains). There are actually 3 major sources of phosphates: natural phosphates (as cellular and protein constituents) contained in raw or unprocessed foods, phosphates added to foods during processing, and phosphates in dietary supplements/medications.

Russo *et al.*[108] assessed the effect of dietary phosphate restriction on the progression of CAC. This study was not designed to compare the efficacy of phosphate binders against dietary phosphate restriction. However, they found that dietary phosphate restriction alone did not lead to a decrease in urinary phosphate excretion, nor did it prevent progression of CAC. However, the urine data cast doubt on compliance with the diet, and there was no control group on a normal or high-phosphate diet.

Aggressive dietary phosphate restriction is difficult because it has the potential to compromise adequate intake of other nutrients, especially protein. Zeller *et al.*[109] showed that the restriction of dietary protein and phosphate could be achieved with maintenance of good nutrition status with intense counseling. They demonstrated that dietary protein/phosphate restriction resulted in a significant reduction in urinary phosphate excretion when compared with a control diet.

Dietary supplements and over-the-counter or prescription medications are hidden sources of phosphate. They may contain phosphate salts within their inactive ingredients. The data on the amount of phosphate in oral medications and vitamin/mineral supplements is limited, but they have the potential to contribute significantly to the phosphate load considering the number of medications CKD patients are required to take.[110,111]

Another consideration for modification of dietary phosphate and control of serum phosphate is the "bioavailability" of phosphorus in different foods based on the form—organic versus inorganic sources of phosphate. Animal- and plant-based foods contain the organic form of phosphate. Food additives contain inorganic phosphate. About 40% to 60% of animal-based phosphate is absorbed, depending on the GI vitamin D receptor activations. Plant phosphate, mostly associated with phytates, is less absorbable (generally 20%–50%) in the human GI tract. It behooves the dietitian and other interdisciplinary staff to include education about the best food choices as they relate to absorbable phosphate. Additionally, it is important for patients to be guided toward fresh and homemade foods rather than processed foods in order to avoid additives.

Organic phosphate in such plant foods as seeds and legumes is less bioavailable because of limited GI absorption of phytate-based phosphorus. In this context, Moe *et al.*[35] recently demonstrated that a vegetable-based diet showed significantly lower phosphate absorption versus a meat-based diet with similar phosphate content. Inorganic phosphate is more readily absorbed, and its presence in additive-laden processed, preserved, or enhanced foods or soft drinks is likely to be underreported in nutrient databases. Hence, the phosphate burden from food additives is disproportionately high relative to natural sources that are derived from organic (animal and vegetable) food proteins, and these additives are almost completely absorbed in the GI tract. For example, Benini *et al.* showed that foods that contain phosphate additives have a phosphorus content nearly 70% higher than those that do not contain additives.[112] Sherman and Mehta also demonstrated that phosphate contents between unprocessed and processed meat or poultry may differ by more than 60%, and thus the absorbable phosphate may even be 2 to 3 times higher per weight in processed food.[113]

In contrast, many of the foods that are traditionally labeled as high phosphorus may be more acceptable with the knowledge that the phosphorus is absorbed more slowly and not as efficiently. For example, beans and nuts have always been listed as very high in phosphorus; however, considering their lower absorption rate, they may be acceptable as protein sources, if they are not too high in other nutrients such as potassium.

The amount of phosphorus contributed by food intake is increasing with current and new processing practices that utilize phosphorus-containing ingredients, including popular foods such as restructured meats (formed, pressed, rolled, and shaped for ease of preparation and ingestion), processed and spreadable cheeses, "instant" products (puddings, sauces), frozen breaded products, and soft drinks.[114] Phosphate additives are also widely used in fast foods and convenience foods that are fully or partially pre-made or instant.[110]