Effect of Food Additives on Hyperphosphatemia Among Patients With End-stage Renal Disease
A Randomized Controlled Trial

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Individuals with moderate to severe renal disease have an impaired ability to excrete phosphorus. As a result, they tend to develop hyperphosphatemia, especially in settings of high phosphorus intake. Elevated serum phosphorus levels are independently associated with increased mortality and morbidity. For example, serum phosphorus levels greater than the 5.5-mg/dL level recommended by practice guidelines are independently associated with a 20% to 40% increase in mortality risk among patients with end-stage renal disease (ESRD).¹⁻⁹ In addition, hyperphosphatemia appears to be involved in the development of atherosclerotic heart disease, secondary hyperparathyroidism, and bone disease among renal patients.¹⁰⁻¹²

High phosphorus intake may also be detrimental for the general public. The dietary phosphorus intake of individuals in the United States has been increasing, while intake of calcium has been decreasing.¹³ There is evidence to suggest that these intake patterns interfere with the normal process of calcium regulation and affect both peak bone mass and rate of bone loss, even

Context High dietary phosphorus intake has deleterious consequences for renal patients and is possibly harmful for the general public as well. To prevent hyperphosphatemia, patients with end-stage renal disease limit their intake of foods that are naturally high in phosphorus. However, phosphorus-containing additives are increasingly being added to processed and fast foods. The effect of such additives on serum phosphorus levels is unclear.

Objective To determine the effect of limiting the intake of phosphorus-containing food additives on serum phosphorus levels among patients with end-stage renal disease.

Design, Setting, and Participants Cluster randomized controlled trial at 14 long-term hemodialysis facilities in northeast Ohio. Two hundred seventy-nine patients with elevated baseline serum phosphorus levels (>5.5 mg/dL) were recruited between May and October 2007. Two shifts at each of 12 large facilities and 1 shift at each of 2 small facilities were randomly assigned to an intervention or control group.

Intervention Intervention participants (n=145) received education on avoiding foods with phosphorus additives when purchasing groceries or visiting fast food restaurants. Control participants (n=134) continued to receive usual care.

Main Outcome Measure Change in serum phosphorus level after 3 months.

Results At baseline, there was no significant difference in serum phosphorus levels between the 2 groups. After 3 months, the decline in serum phosphorus levels was 0.6 mg/dL larger among intervention vs control participants (95% confidence interval, −1.0 to −0.1 mg/dL). Intervention participants also had statistically significant increases in reading ingredient lists (P<.001) and nutrition facts labels (P=.04) but no significant increase in food knowledge scores (P=.13).

Conclusion Educating end-stage renal disease patients to avoid phosphorus-containing food additives resulted in modest improvements in hyperphosphatemia.
among individuals with normal renal function.\textsuperscript{13-17}

To prevent hyperphosphatemia, patients with ESRD limit their intake of foods that are naturally high in phosphorus such as meats, dairy products, whole grains, and nuts. However, phosphorus-containing additives are increasingly being added to processed and fast foods, particularly meats, cheeses, baked goods, and beverages. These phosphate salts are used to preserve moisture or color, to emulsify ingredients and enhance flavor, and to stabilize foods.\textsuperscript{18,19} Phosphorus-containing additives are the most rapidly growing source of dietary phosphorus over the last 2 decades and may contribute additives are the most rapidly growing source of dietary phosphorus over the last 2 decades and may contribute to one-third of overall phosphorus intake of foods.\textsuperscript{21} The use of such additives makes it difficult for both renal patients and their clinicians to estimate the phosphorus content of foods.\textsuperscript{21}

Phosphorus-containing additives have been shown to increase serum phosphorus in short-term experimental studies involving small numbers of participants.\textsuperscript{22,23} However, their impact in real-world situations is less clear. To determine if there is a causal relationship between additive consumption and hyperphosphatemia, it would be necessary to demonstrate in a prospective clinical trial that altering additive consumption leads to changes in serum phosphorus levels. We therefore sought to test an educational intervention to reduce the intake of additive-containing processed and fast foods. We focused on patients with severe renal disease because they are likely to be the most sensitive to changes in dietary phosphorus.\textsuperscript{24}

METHODS
Participants and Facilities
All 14 long-term hemodialysis facilities that belong to the 2 largest chains in the Cleveland, Ohio, area agreed to participate. Virtually all hemodialysis patients receive treatment 3 times weekly on Monday, Wednesday, and Friday (MWF shift) or on Tuesday, Thursday, and Saturday (TTS shift). We randomized at the level of dialysis shift to avoid the possibility that study activities performed with intervention participants might contaminate control participants. Twelve facilities offer both MWF and TTS shifts. For each of these facilities, a data manager used a random number generator to assign one randomly selected shift to the intervention group and the other shift to the control group. Two facilities only offer MWF shifts. The data manager used a random number generator to randomly assign one of these facilities to the intervention group and the other to the control group.

To determine eligibility, study coordinators abstracted medical records to identify patients for whom the most recent serum phosphorus level and mean serum phosphorus level for the previous 3 months were both greater than 5.5 mg/dL (to convert phosphorus to millimoles per liter, multiply by 0.323). This ensured that only patients with phosphorus levels that were persistently above those recommended by practice guidelines were included.\textsuperscript{1} Additional patient eligibility criteria were age of 18 years or older and receiving long-term hemodialysis for at least 6 months. We excluded new patients because the first several months of dialysis treatment is often a time of changes in diet and nutritional measures. We also excluded patients who could not participate (did not speak English or were mentally impaired) or were likely to have unique nutritional requirements (nursing home resident, AIDS, active malignancy, terminal illness).

Study coordinators approached eligible patients during a dialysis treatment, told them about the goals of the study and specific intervention or control group tasks, and obtained written informed consent. Each participant was given $10 at the beginning and again at the end of the trial to thank him/her for participation. This study was approved by the institutional review board of MetroHealth Medical Center, Cleveland, Ohio.

Baseline Assessment
Unblinded study coordinators abstracted medical records of intervention and control participants to obtain demographic characteristics (age, sex, self-reported race/ethnicity), medical characteristics (cause of renal failure, time receiving dialysis), laboratory test results (serum albumin, calcium, phosphorus, and parathyroid hormone levels), and current use of specific medications. We assessed race/ethnicity to help compare the demographic characteristics of our participants with dialysis patients nationally. The medication review focused on phosphorus binders (sevelamer, calcium acetate, lanthanum, calcium carbonate), the calcimimetic drug cinacalcet, and vitamin D analogues. The laboratory test results were abstracted for the 3 months prior to study enrollment. The participating hemodialysis facilities generally obtain these tests on a monthly basis for each patient.

To assess knowledge related to phosphorus content, study coordinators asked intervention and control participants to identify high-phosphorus foods from a list of 20 foods. This list included 16 foods that contain large amounts of phosphorus (dried beans, biscuits, pancake mix, breakfast cereal, frozen chicken nuggets, pudding cup, toaster pastry, hot dog, fruit punch, American cheese, cola, quick-frozen chicken breast, bacon, whole-wheat bread, bran cereal, breaded chicken sandwich) and 4 foods that contain minimal amounts of phosphorus (green beans, French bread, pretzels, apple juice). Participants then used...
Likert scales to respond to questions about their urine output and about how often they read nutrition facts labels, read ingredient lists, and ate meals from specific fast-food restaurants. The study coordinator also asked if someone else (eg, a family member or friend) was responsible for grocery shopping for the patient. All questions were developed with the help of a panel of renal dietitians and hemodialysis patients and were pilot tested prior to use for this study.

**Intervention Group**
A study coordinator met in person with each intervention participant during a dialysis treatment in the first month of the study. She provided approximately 30 minutes of education regarding phosphorus-containing additives and their effect on the phosphorus content of foods. During this educational session, the coordinator provided each intervention participant with a small magnifier in a plastic case. The names of common phosphorus-containing additives (dicalcium phosphate, hexametaphosphate, monocalcium phosphate, phosphoric acid, pyrophosphate, sodium acid pyrophosphate, sodium aluminum phosphate, sodium phosphate, sodium triplyphosphate, tricalcium phosphate) were printed on the case. The study coordinator instructed participants to use the magnifier and list of additives when they purchased food at grocery stores. Specifically, the coordinator asked participants to avoid purchasing any items whose ingredient lists include phosphorus-containing additives. If someone else was responsible for grocery shopping for the patient, then this individual was asked to attend the educational session as well.

The coordinator also gave each intervention participant a handout. Each handout listed specific menu items to be avoided because they contained phosphorus additives. The handouts also listed better choices that were free of phosphorus additives and were also compatible with other renal dietary requirements.

The study coordinator telephoned intervention participants during the second month of the study to reinforce the instructions and to answer any questions. Because the study coordinators carried out the intervention, it was not possible for them to be blinded to patients’ assignments to intervention vs control groups.

**Control Group**
Control participants continued to receive care from their dietitians and nephrologists. A study coordinator telephoned control participants during the second month of the study and asked questions about how often they read nutrition facts labels and ingredient lists, ate meals from fast-food restaurants, and received phosphorus-related recommendations from their facility dietitian. However, control participants did not receive any education or feedback from study coordinators.

**Follow-up Procedures**
All participants were recruited between May and October 2007 and were followed up for 3 months or until they died or moved. The final assessment occurred in the third month of the study. Study coordinators abstracted medical records of intervention and control participants to obtain laboratory test results (serum albumin, calcium, phosphorus, and parathyroid hormone levels) for each of the 3 prior months. Study coordinators asked intervention and control participants to identify high-phosphorus foods from the same list of 20 foods used as part of the baseline assessment. They also asked participants about how often they read nutrition facts labels, read ingredient lists, and ate meals from fast-food restaurants. No participants changed their shifts during the study duration.

**Outcomes**
The primary outcome measure was change in serum phosphorus level. We defined baseline serum phosphorus level as the value obtained in the month prior to study enrollment and final serum phosphorus level as the value obtained 3 months after participant enrollment. We calculated change in phosphorus level as final minus baseline values. Secondary outcomes were changes in nutritional knowledge and in reading ingredient lists and nutrition facts labels. These 3 variables were transformed to a 0-to-100 scale in which 0 indicates the lowest possible knowledge score or reading behavior and 100 indicates the highest possible knowledge score or reading behavior.

**Statistical Analysis**
We used the t test, the χ² test, and the Mann-Whitney rank sum test to compare the baseline characteristics of intervention and control participants. To simplify presentation of results, some Likert scale responses were dichotomized. However, the corresponding P values are based on the complete ordinal scales used by participants to respond to questions about their urine output and about how often they ate meals from specific fast-food restaurants. We used multiple imputation to account for missing data from 28 participants who failed to complete the study because they died, moved, withdrew, received a transplant, or were hospitalized and did not return to outpatient dialysis by the end of the study. Specifically, we performed multiple imputation by chained equations, an iterative multivariable regression technique, based on 5 imputations and included all baseline characteristics of participants as covariates.

We used a difference-in-differences approach to examine the effect of the intervention on study outcomes. We first examined changes in phosphorus levels within each group. We then estimated the effect of the intervention by examining the difference between the mean change among intervention participants and the mean change among control participants.
trol participants. We used the t test to assess if this difference in differences was significantly different from zero. We used a similar approach to examine secondary outcomes. All analyses were performed using Stata software version 9.2 (StataCorp, College Station, Texas) and adjusted for potential clustering of participants within both dialysis facilities and shifts.28 All P values represent 2-sided hypothesis tests, and the significance level was .05.

Based on prior work, we anticipated that the standard deviation of change in serum phosphorus level would be approximately 1.25 mg/dL. To detect a clinically important effect size of 0.5 mg/dL (or standardized effect size of 0.4) would require 196 total participants with a 2-tailed α level of .05 and 80% power.

RESULTS

Participant Characteristics

The Figure shows the flow of participants through the trial. Two hundred seventy-nine patients began the trial, including 145 intervention participants and 134 control participants. A total of 1636 patients did not meet eligibility criteria: 84% did not have persistently elevated serum phosphorus levels, 7% could not participate (eg, they were mentally impaired), 6% had unique nutritional requirements, and 3% were new to dialysis. One hundred fifty-two eligible patients declined to participate. These 152 nonparticipants were somewhat older than the 279 participants (56 vs 53 years; P = .01) but did not differ in other demographic characteristics or in serum phosphorus levels.

Intervention and control participants had generally similar baseline characteristics. The most common causes of renal failure were diabetes and hypertension (Table 1). Only a small proportion of participants reported substantial urine output. Sevelamer and calcium acetate were the most commonly used phosphorus binders in both groups. About half of the participants reported eating fast food more frequently than once per week. At the beginning of the trial, the mean serum phosphorus level was 7.2 mg/dL among intervention participants and 7.1 mg/dL among control participants (P = .73). Food knowledge score and reading nutrition facts labels were similar in both groups, but control participants were more likely to report reading ingredient lists.

Changes in Nutritional Measures

After 3 months, serum phosphorus levels declined by 1.0 mg/dL among intervention participants (P < .001; Table 2) and by 0.4 mg/dL among control participants (P = .02). Thus, the decline in serum phosphorus levels was 0.6 mg/dL larger among intervention vs control participants (95% confidence interval, −1.0 to −0.1 mg/dL). Intervention participants also had significantly larger increases in reading ingredient lists and nutrition facts labels compared with control participants. There were no adverse events or adverse effects associated with the intervention.

COMMENT

We found that educating patients with ESRD to avoid phosphorus-containing food additives resulted in modest but clinically significant improvements in serum phosphorus levels. The 0.6-mg/dL larger decline in average phosphorus level among intervention participants compared with control participants corresponds to a 5% to 15% reduction in relative mortality risk in observational studies.2-7,9

Our intervention has the advantages of being simple, low-cost, and easy to implement. Another strength of the study is its randomized design, which resulted in generally similar intervention and control groups in terms of recruitment rates and baseline demographic, medical, and nutritional characteristics (Figure and Table 1). With the exception of race, participant characteristics were generally similar to those of patients nationally.20 The large number of black participants reflects the inner-city location of many of the participating facilities.

Although we were unable to assess actual dietary intake, the increased reading of nutrition facts labels and ingredient lists reported by intervention participants (Table 2) suggests that improvements in serum phosphorus levels were mediated by changes in par-
participant behavior and food choices that were consistent with the intent of the intervention. This makes it likely that a causal link exists between changes in the consumption of such additives and changes in serum phosphorus levels among patients with advanced renal disease. Our findings raise the possibility that typical intakes of processed and fast foods contribute to the persistent hyperphosphatemia, cardiovascular events, and bone disease observed among patients with ESRD.24,30

Our results have important implications for patients, clinicians, researchers, and policy makers. Patients with ESRD and clinicians should learn about both naturally occurring phosphorus and phosphorus-containing additives, and patients should limit their total phosphorus intake to 800 to 1000 mg/d as recommended by practice guidelines.1 However, this is likely to be challenging for several reasons. First, the high phosphorus content of additive-containing products makes it difficult for patients to adhere to intake guidelines. For example, just 2 servings of additive-containing chicken products provide an average of 880 mg of phosphorus.21 Second, ingredient lists are often unavailable at fast-food and other restaurants. Even when ingredient lists are available, it is not possible to quantitatively estimate phosphorus content. For example, recent laboratory analyses revealed that there are 2-fold variations in the phosphorus content of chicken products purchased from grocery stores.21 Third, the widespread use of phosphorus-containing additives combined with other renal dietary restrictions greatly limits acceptable food choices. On average, only one-sixth of entrees and side dishes at fast-food restaurants are suitable for patients with ESRD. Moreover, there are no suitable entrees or side dishes at several fast-food restaurants.26 Fourth, phosphorus in additives is more readily ab-

### Table 1. Baseline Characteristics of Intervention and Control Participants

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Intervention (n = 145)</th>
<th>Control (n = 134)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean (SD), y</td>
<td>54 (13)</td>
<td>52 (13)</td>
<td>.41</td>
</tr>
<tr>
<td>Male</td>
<td>83 (57)</td>
<td>88 (66)</td>
<td>.15</td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black</td>
<td>99 (68)</td>
<td>94 (70)</td>
<td>.65</td>
</tr>
<tr>
<td>White</td>
<td>39 (27)</td>
<td>31 (23)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>7 (5)</td>
<td>9 (7)</td>
<td></td>
</tr>
<tr>
<td>Cause of renal failure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diabetes</td>
<td>55 (38)</td>
<td>43 (32)</td>
<td>.38</td>
</tr>
<tr>
<td>Hypertension</td>
<td>42 (29)</td>
<td>52 (39)</td>
<td></td>
</tr>
<tr>
<td>Glomerulonephritis</td>
<td>29 (20)</td>
<td>23 (17)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>19 (13)</td>
<td>16 (12)</td>
<td></td>
</tr>
<tr>
<td>Receiving dialysis, mean (SD), y</td>
<td>4.5 (3.7)</td>
<td>4.6 (4.6)</td>
<td>.83</td>
</tr>
<tr>
<td>Urine output &gt;2 c/d</td>
<td>24 (17)</td>
<td>32 (24)</td>
<td>.12</td>
</tr>
<tr>
<td>Phosphorous level, mean (SD), mg/dL</td>
<td>7.2 (1.2)</td>
<td>7.1 (1.0)</td>
<td>.73</td>
</tr>
<tr>
<td>Parathyroid hormone level, mean (SD), pg/mL</td>
<td>630 (580)</td>
<td>800 (900)</td>
<td>.04</td>
</tr>
<tr>
<td>Calcium level, mean (SD), mg/dL</td>
<td>8.9 (8.0)</td>
<td>9.0 (8.0)</td>
<td>.47</td>
</tr>
<tr>
<td>Albumin level, mean (SD), g/dL</td>
<td>3.9 (.4)</td>
<td>4.0 (.4)</td>
<td>.09</td>
</tr>
<tr>
<td>Taking sevelamer</td>
<td>78 (54)</td>
<td>84 (63)</td>
<td>.12</td>
</tr>
<tr>
<td>Taking calcium acetate</td>
<td>61 (42)</td>
<td>48 (36)</td>
<td>.40</td>
</tr>
<tr>
<td>Taking lanthanum</td>
<td>18 (12)</td>
<td>8 (6)</td>
<td>.16</td>
</tr>
<tr>
<td>Taking calcium carbonate</td>
<td>6 (4)</td>
<td>7 (5)</td>
<td>.80</td>
</tr>
<tr>
<td>Taking multiple binders</td>
<td>22 (15)</td>
<td>20 (15)</td>
<td>.88</td>
</tr>
<tr>
<td>Taking vitamin D analogue</td>
<td>108 (74)</td>
<td>94 (70)</td>
<td>.41</td>
</tr>
<tr>
<td>Taking cinacalcet</td>
<td>44 (30)</td>
<td>36 (27)</td>
<td>.54</td>
</tr>
<tr>
<td>Food knowledge score, mean (SD)</td>
<td>67 (16)</td>
<td>66 (16)</td>
<td>.56</td>
</tr>
<tr>
<td>Ingredients</td>
<td>53 (36)</td>
<td>62 (35)</td>
<td>.02</td>
</tr>
<tr>
<td>Nutrition facts labels, mean (SD)</td>
<td>58 (36)</td>
<td>59 (39)</td>
<td>.74</td>
</tr>
<tr>
<td>Eats fast food more than once weekly</td>
<td>71 (49)</td>
<td>64 (48)</td>
<td>.94</td>
</tr>
</tbody>
</table>

### Table 2. Primary and Secondary Outcomes Among 145 Intervention and 134 Control Participants

<table>
<thead>
<tr>
<th></th>
<th>Intervention</th>
<th>Control</th>
<th>Difference in Differences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphorous level, mg/dL</td>
<td>7.2 (1.2)</td>
<td>6.2 (1.7)</td>
<td>−1.0 (−1.3 to −0.7) &lt;.001</td>
</tr>
<tr>
<td>Food knowledge score</td>
<td>67 (16)</td>
<td>74 (14)</td>
<td>7 (5 to 10) &lt;.001</td>
</tr>
<tr>
<td>Reads ingredient list</td>
<td>53 (36)</td>
<td>77 (28)</td>
<td>24 (17 to 30) &lt;.001</td>
</tr>
<tr>
<td>Reads nutrition facts labels</td>
<td>57 (36)</td>
<td>76 (28)</td>
<td>19 (12 to 26) &lt;.001</td>
</tr>
</tbody>
</table>

### Abbreviation

CI, confidence interval.

SI conversion factors: To convert phosphorus to mmol/L, multiply by 0.323. To convert parathyroid hormone to pmol/L, multiply by 0.11. To convert calcium to mmol/L, multiply by 0.25. To convert albumin to g/L, multiply by 10.

Data are expressed as number (percentage) of participants unless otherwise indicated.

Measured on a 0-to-100 scale in which 0 indicates the lowest knowledge or reading behavior and 100 indicates the highest knowledge or reading behavior.
sorbed than that from foods naturally high in phosphorus. As a result, additives may have a greater impact on hyperphosphatemia than an equivalent amount of naturally occurring phosphorus.

Researchers should focus on developing more potent approaches to preventing and treating hyperphosphatemia. Despite the widespread use of high-efficiency dialyzers, new pharmacologic treatments, and regular nutritional education, one-third to half of dialysis patients nationally have elevated serum phosphorus levels. Although our intervention participants had significant declines in hyperphosphatemia, their mean serum phosphorus level was still higher than the 5.5-mg/dL threshold recommended by practice guidelines. Researchers should also focus on understanding the impact of additives on patients with less severe renal disease and on the general public. It is likely that hyperphosphatemia contributes to cardiovascular and bone disease among the 10 million individuals in the United States with moderate kidney disease. There is also evidence to suggest that high phosphorus intake and hyperphosphatemia may lower bone density, increase fracture risk, and contribute to cardiovascular events among individuals with normal renal function.

Policy makers should consider both the health costs associated with high phosphorus intake and hyperphosphatemia as well as policy approaches to address this problem. Medicare expenditures for ESRD patients are more than $23 billion annually, with a substantial proportion due to cardiovascular and bone disease. The cost implications will be even greater if high phosphorus intake and hyperphosphatemia contribute to health expenditures among individuals with less severe renal disease and the general public. Policy approaches may include mandating that phosphorus content be listed on nutrition facts labels (as calories, fat, and sodium already are). Although manufacturers may voluntarily include phosphorus content on such labels, most foods do not have this information. For example, we found that phosphorus content was not listed on any of 38 representative chicken products purchased in grocery stores even though 92% of these products contained phosphorus additives. Mandatory labeling of phosphorus content may help patients to better monitor and limit their phosphorus intake and may encourage manufacturers to limit the use of phosphorus-containing additives. It is worth noting that many manufacturers eliminated or greatly reduced the trans fat content of their products in response to a recent mandate to include trans fat on nutrition facts labels. Other approaches may involve creating incentives for producing and marketing low-phosphorus products and funding alternatives to phosphorus-containing additives.

Several limitations must be considered in interpreting our findings. Our participant sample was modest in size and was drawn from a single geographic area, we did not have information on adherence, our power to discern changes in secondary outcomes was limited, and many participants failed to improve despite our intervention. The duration of follow-up was limited to 3 months, so the long-term impact of this intervention on morbidity and mortality is unclear. Although it is likely that our intervention would be helpful for patients with lower serum phosphorus levels, our study only focused on patients with persistently elevated levels. It is also possible that some control participants began reading nutrition facts labels and ingredient lists (Table 2) or altered their phosphorus intake because they were asked questions about these practices (referred to as the Hawthorne effect). However, control participants did not receive specific education about phosphorus-containing additives, and their serum phosphorus levels were unchanged. It is also possible that some control participants were influenced by study activities directed at intervention patients (referred to as contamination). Both the Hawthorne effect and contamination would tend to decrease the difference between groups. Therefore, the measured effect size may underestimate the value of our intervention.

In conclusion, educating patients with ESRD to avoid phosphorus-containing food additives results in modest improvements in hyperphosphatemia. Further work is needed to enhance the potency of our intervention and to understand the impact of phosphorus-containing additives on patients with less severe renal disease and on the general public.

Author Contributions: Dr Sehgal had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Sullivan, Sayre, Leon, Sehgal. Acquisition of data: Sullivan, Sayre, Porter. Analysis and interpretation of data: Sullivan, Sayre, Leon, Macheckano, Love, Porter, Marbury, Sehgal. Drafting of the manuscript: Sehgal. Critical revision of the manuscript for important intellectual content: Sullivan, Sayre, Leon, Macheckano, Love, Porter, Marbury. Statistical analysis: Sullivan, Macheckano, Love, Porter, Sehgal. Obtained funding: Leon, Sehgal. Administrative, technical, or material support: Sullivan, Sayre, Leon, Porter, Marbury, Sehgal. Study supervision: Sullivan, Leon, Sehgal.

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Additional Contributions: We are grateful to the patients and dialysis facilities who participated in this project.

REFERENCES


