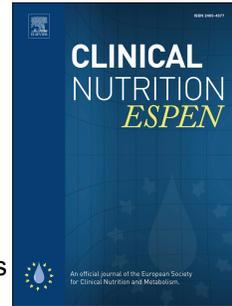


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Phosphorus nutritional knowledge among dialysis health care providers and patients: a multicenter observational study

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1 **Phosphorus nutritional knowledge among dialysis health care providers and**
2 **patients: a multicenter observational study**

3

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49 **ABSTRACT**

50 **Background - Aims:** Phosphorus nutritional knowledge level of hemodialysis patients
51 and renal nurses has been found to be low, while respective knowledge of nephrologists
52 has not been studied yet. There are equivocal results regarding the association of
53 phosphorus nutritional knowledge level and serum phosphorus values. The aim of this
54 study was to assess phosphorus nutritional knowledge of hemodialysis patients,
55 nephrologists and renal nurses and seek potential interventions to improve patients'
56 adherence to phosphorus and overall nutritional guidelines.

57 **Methods:**

58 This cross-sectional observational study was conducted on sixty eight hemodialysis
59 patients, 19 renal nurses and 11 nephrologists who were recruited from 3 hemodialysis
60 units in Greece. Phosphorus nutritional knowledge of the participants was assessed by a
61 25-item questionnaire (CKDKAT-N) which included 15 questions on phosphorus
62 and 10 questions on protein, sodium, and potassium knowledge.

63 **Results:** Nephrologists had higher CKDKAT-N total (19.1 ± 3.6 vs 14.1 ± 2.8 and $13.2 \pm$
64 2.8 , $P < 0.01$) and phosphorus knowledge scores (10.6 ± 2.7 vs 7.6 ± 2.2 and 7.3 ± 2.0 ,
65 $P < 0.01$) compared to renal nurses and patients respectively. There were no differences in
66 total and phosphorus knowledge scores between nurses and patients. Patients and nurses
67 answered correctly significantly less questions regarding phosphorus compared with the
68 rest of the questions ($P < 0.01$) while no such difference was found in nephrologists.
69 Serum phosphorus was positively correlated with phosphorus knowledge score ($r = 0.31$,
70 $P = 0.02$), and negatively correlated with patient age ($r = -0.34$, $P < 0.05$). None of the

71 patients, 11% of the nurses and 27% of the nephrologists answered correctly all three
72 questions regarding P, K and Na dietary recommendations ($P<0.01$).

73 **Conclusions:** The study confirms that hemodialysis patients have low renal nutrition
74 knowledge while higher nutritional phosphorus knowledge does not lead to lower serum
75 phosphorus values. Alarming, renal nurses have been found to have a similar level of
76 knowledge with hemodialysis patients, something that needs to be taken into account
77 when training the new dialysis staff. Nephrologists have superior knowledge; however
78 they are still lacking essential nutritional knowledge that could affect patients' and
79 nurses' overall understanding. Continuing education on nutrition of nephrologists and
80 renal nurses could improve nutrition care of hemodialysis patients.

81

82 **Key words:** phosphorus knowledge, hemodialysis, nephrologists, renal nutrition

83 INTRODUCTION

84 Hyperphosphatemia is a significant and frequent problem in hemodialysis patients (1, 2).

85 In this population, increased phosphorus levels are considered an important risk factor for
86 cardiovascular disease (3, 4) and one of the major components of chronic kidney disease,
87 mineral and bone disorder (5).

88 Even though, during a typical hemodialysis session, 600 - 1200 mg phosphorus can be
89 removed (6) and phosphate binding medication is able to bind approximately 200–300
90 mg of phosphorus per day (7), hemodialysis patients need to monitor and control their
91 dietary phosphorus intake in order to achieve target serum phosphorus levels (8). Dietary
92 phosphorus intake has been shown to range from 1000 - 1800 mg depending on diet,
93 cooking methods and the consumption of foods with additives or not (9-11).

94 Apart from phosphorus, hemodialysis patients are asked to conform to multiple dietary
95 restrictions regarding energy, protein, fluid, sodium, potassium and calcium (12, 13). Due
96 to the complexity of dietary advice the majority of the patients are having difficulties in
97 understanding, applying and adhering in the long term (14, 15).

98 In studies investigating hemodialysis patients' nutritional knowledge, it has been found
99 that patients can not easily identify foods that are high and low in phosphorus (16-18),
100 and that knowledge of phosphorus is the lowest compared to knowledge of other nutrients
101 important for the management of end stage renal disease (sodium, potassium and fluid)
102 (16, 19, 20).

103 Nephrologists and renal dietitians (where available) are the main sources of dietary
104 information for dialysis patients. Apart from them, renal nurses are the ones closest to the
105 patients and can provide appropriate suggestions, advice, or recommendations (20) while

106 their role is deemed essential to identify and reinforce each component of optimal care
107 (13). Nutritional knowledge of renal nurses has been found to be superior to that of the
108 patients', but phosphorus knowledge is poor (20). Nephrologists' dietary phosphorus
109 knowledge level has not been yet assessed and reported.

110 The purpose of the current study was to assess nutritional knowledge, with a special focus
111 in phosphorus, of hemodialysis patients, nephrologists and renal nurses.

112

113 **MATERIALS AND METHODS**

114 **Participants**

115 Data were collected from 3 hemodialysis units in Greece (2 university hospitals and 1
116 general hospital). The study included patients receiving hemodialysis 3 times a week for
117 more than 3 months (46 male, 22 female), hemodialysis unit renal nurses (working in the
118 hemodialysis units for more than 6 months), and unit nephrologists. Serum phosphorus,
119 calcium data and albumin data were obtained from patients' last 3 recorded analyses
120 closer to the day of the study. A 3 month average value of serum phosphorus and calcium
121 was calculated for each patient. Nutritional status of the patients was assessed using
122 Subjective Global Assessment (21).

123 All patients had received general guidelines regarding diet in dialysis by the unit
124 nephrologists. None of the units was regularly covered by a renal dietitian. The study was
125 approved by all of the three hospitals ethics committees.

126

127 **Nutritional knowledge level evaluation**

128 Nutritional knowledge was evaluated using a previously published 25 item multiple -
129 choice questionnaire, which includes 15 questions concerning phosphorus and 10
130 questions concerning protein, sodium, and potassium (CKDKAT-N) (19). Each correct
131 answer was worth one point. Apart from total score, knowledge scores for phosphorus
132 and the other nutrients were calculated.

133 The questionnaire was administrated by interview by a qualified clinical dietitian (ZP). In
134 3 questions which included foods not usually consumed in Greece, items were replaced
135 with Greek foods with the same nutrient profile using Greek food composition tables (22)
136 as suggested by the clinical dietitian.

137

138 **STATISTICAL ANALYSIS**

139 One way analysis of variance (ANOVA) was used to compare differences of the
140 independent variables among groups. Tukey HSD test was used for post hoc analysis.
141 The Pearson correlation coefficient was used to assess the relationship between the
142 examined variables. Data are presented as mean \pm standard deviation and the significance
143 was set at $p \leq 0.05$. Data was analyzed using the SPSS Statistical Package version 22.

144

145 **RESULTS**

146 Eighty eight patients, 32 nurses and 24 nephrologists initially agreed to be interviewed,
147 however, complete data was obtained only from 68 patients (77.3%), 19 renal nurses
148 (59.4%) and 11 nephrologists (45.8%) due to availability reasons.

149 Patient characteristics are shown in Table 1. According to SGA, 72.1% of the patients
150 were classified as well nourished (SGA-A), 26.5% as moderately malnourished (SGA-B)
151 and 1.5% (1 patient) as severely malnourished (SGA-C).

152 Patient, nurse and nephrologists' total, phosphorus, and the sum of sodium, potassium and
153 protein (rest section) CKDKAT-N knowledge scores are shown in Table 2. Patients and
154 nurses answered correctly a greater percentage of questions related to sodium, potassium
155 and protein than those referred to phosphorus ($P < 0.01$ for both groups) (Figure 1). There
156 were no differences between the percentage of correct answers to phosphorus and the rest
157 section of CKDKAT-N for the unit nephrologists ($73 \pm 16\%$, $75 \pm 18\%$ respectively).
158 Correlation coefficients for total and phosphorus knowledge scores in all three groups of
159 participants (patients, nurses and doctors) are shown in Table 3.

160 In patients, total knowledge score (max 25) and phosphorus knowledge score (max 15)
161 ranged from 6 (N=1) to 18 (N=1) and 2 (N=1) to 12 (N=1) respectively. Sixty nine
162 percent (69%) of the patients answered correctly more than half of all the questions,
163 whereas no patient had a total score >20 . In renal nurses, total and phosphorus knowledge
164 scores ranged from 6 (N=1) to 17 (N=4) and 1 (N=1) to 12 (N=1) respectively. Seventy
165 four percent (74%) of the nurses answered correctly more than half of the CKDKAT-N
166 questions, whereas no one had a total score >20 . In nephrologists, total and phosphorus
167 knowledge scores ranged from 12 (N=1) to 25 (N=1) and 7 (N=1) to 15 (N=1)
168 respectively, and 36% of the doctors had a total CKDKAT-N score >20 .

169 In patients there were no differences in any of the measured or calculated variables
170 between sexes, and the only significant difference in knowledge scores between different
171 hemodialysis units was that Unit 3 patients had significantly higher CKDKAT-N

172 phosphorus knowledge scores compared with Unit 1 and 2 patients (8.2 ± 1.5 vs $6.7 \pm$
173 2.1 , respectively, $P < 0.02$).

174 Patient age ranged from 18.8 to 79.9 yrs, and hemodialysis duration ranged from 0.3 to
175 27 yrs. When patients were categorized according to age (< 40 yrs, $40-60$ yrs and ≥ 60
176 yrs), the ones in the middle category ($40-60$ yrs) had significant higher total knowledge
177 scores compared with patients ≥ 60 yrs ($P < 0.05$), and higher phosphorus knowledge
178 scores compared with both the other groups ($P < 0.05$). Total knowledge scores were: 14.2
179 ± 2.1 , 15.0 ± 2.7 , 12.7 ± 3.0 , and phosphorus scores: 7.6 ± 1.4 , 7.8 ± 1.9 and 6.3 ± 2.1 for
180 patients < 40 , $40-60$ and ≥ 60 yrs respectively. There were no significant correlations
181 between duration of dialysis and total or phosphorus knowledge scores.

182 Thirty nine percent of the patients for whom serum phosphorus values were available had
183 levels above 5.5 mg/dL.

184 Serum phosphorus was positively correlated with phosphorus knowledge score ($r = 0.31$,
185 $P = 0.02$), and negatively correlated with patient age ($r = -0.34$, $P < 0.05$). Patients with
186 serum phosphorus > 5.5 mg/dL tended to have higher phosphorus CKDKAT-N
187 knowledge scores compared to those with serum phosphorus ≤ 5.5 mg/dL (8.1 ± 1.3 vs
188 7.0 ± 2.2 mg/dL, $P = 0.61$).

189 Even though none of the patients had a serum albumin value below 3.6 mg/dL, there was
190 a significant difference in serum albumin values between patient age groups ($P < 0.05$),
191 with patients aged ≥ 60 yrs having significantly lower serum albumin compared to the
192 patients aged $40-60$ yrs (4.1 ± 0.3 mg/dL vs 4.3 ± 0.25 mg/dL respectively, $P < 0.05$).

193 There were no significant correlations between SGA nutritional status classification and
194 albumin, and serum phosphorus and SGA or albumin.

195 **DISCUSSION**

196 This is the first study to assess renal nutrition knowledge among hemodialysis patients,
197 nephrologists and renal nurses. The findings of the current study reveal that for the
198 current cohort of participants, hemodialysis patients' renal nutritional knowledge level is
199 low, while phosphorus knowledge is much lower compared to sodium, potassium and
200 protein knowledge overall. This was also the case for renal nurses, whose total and
201 phosphorus knowledge scores did not differ from the respective patients' scores.
202 Nephrologists, as expected, had superior nutritional knowledge compared to both patients
203 and nurses, but they had a wide range of total and phosphorus knowledge scores, and
204 most of them could not accurately identify the dietary recommendations for hemodialysis
205 patients regarding sodium, potassium and phosphorus (5).

206 Our results for the hemodialysis patients' phosphorus nutritional knowledge are in
207 agreement with the results from the two previous studies that used the CKDKAT-N
208 questionnaire (Figure 1) (19, 20). Similarly, other studies in which other questionnaires
209 were used in order to evaluate nutritional knowledge, have also confirmed that
210 hemodialysis patients' phosphorus nutritional knowledge is low. In one study, 74% of the
211 patients failed to identify foods rich in phosphorus (16), whereas in the study of Durose et
212 al, the mean patient score for knowledge of phosphorus dietary restrictions and medical
213 complications of noncompliance with dietary guidelines was found to be low (53.4%)
214 (18).

215 Renal nurses' total and phosphorus scores were similar, albeit a little lower with the ones
216 found by previous studies (20).

217 Based to the findings of the current study, it seems that the phosphorus-related
218 knowledge score is lower than the respective score related to potassium, sodium and
219 protein. This may be due to the fact that phosphorus is widely spread in nature and foods,
220 and is ingested both as a natural component and as a food additive (7, 11, 23, 24). In
221 addition, the recommendations for higher protein intake are often difficult to dissociate
222 from recommendations for low phosphorus intake, since dietary phosphate restriction has
223 the potential to compromise adequate intake of protein (25-27).

224 In our study the positive correlation between phosphorus nutritional knowledge and
225 serum phosphorus levels adds to the argument that dietary knowledge seems to help to
226 affect serum phosphorus levels only when patients are ready to make nutrition changes
227 and to follow dietary advice (23). Similarly to our results, other studies have reported that
228 better knowledge does not always translate to better adherence to dietary advice and
229 recommended serum phosphate levels (20, 24). Moreover, other studies have found that
230 the hemodialysis patients with higher level of phosphorus food content knowledge and
231 those who exhibit high serum phosphorus complications are the ones with the poorest
232 compliance (18, 24).

233 Another argument for the disagreement of phosphorus nutritional knowledge and serum
234 phosphorus levels might arise from the fact that our results, and that of others, show that
235 older patients seem to have lower serum phosphorus despite worse phosphorus nutritional
236 knowledge (17, 24). However, since serum phosphorus levels have been found to be
237 highly correlated with dietary protein intake (26, 27), low serum phosphorus in older
238 patients might not be affected so much by phosphorus knowledge as from lower protein
239 intake. Our results showing that patients in the older age group had significantly lower

240 albumin compared to younger patient add to that argument, since albumin has been found
241 to be one of the determinants of serum albumin in hemodialysis patients (28).
242 However, as shown by a number of studies, educating hemodialysis patients about
243 phosphorus can lead to a decrement in serum phosphorus levels (16, 23, 29-36). In a
244 review and meta-analysis of studies using different educational strategies to reduce serum
245 phosphorus in dialysis patients it is concluded that any educational intervention results in
246 a 0.72 mg/dL reduction in serum phosphorus; and that the reduction increases to 1.07
247 mg/dL when educational interventions last over 4 months (35). This could be of
248 significant importance for patients, since it has been found that 1 mg/dL increase in
249 serum phosphorus increases mortality by 5-8% in this patient population (37, 38).

250 A closer look to the individual CKDKAT-N answers revealed that the weakest point in
251 nephrologists nutritional knowledge was phosphorus food content, since less than 50% of
252 nephrologists answered correctly 5 from the 9 questions regarding foods high and low in
253 phosphorus (range of correct answers 18 – 45% in these 5 questions). Renal dietitians are
254 the most qualified health care professionals to provide nutritional education for
255 hemodialysis patients, however in Europe, renal dietitians' presence is not compulsory in
256 hemodialysis units (39). The burden and responsibility of patient nutritional education
257 falls to nephrologists, even though renal nurses could play an important role due to their
258 proximity to the patients. It is important to point out that clinical nutrition modules are
259 not part of every medical or nursing school curricula, and when they are available they
260 are frequently described as inadequate (40). We have recently reported that from the 7
261 medical schools in Greece only one includes a nutrition course as compulsory, 3 as
262 elective and the rest do not include a nutrition course in their undergraduate curricula

263 (41). Data from the U.S.A. have also reported that even though the majority of
264 nephrology trainees perceive nutrition training as somewhat or very important, more than
265 50% of them perceive their nutrition training as inadequate (42).

266 As far as Greek nursing schools are concerned, 20% do not include a nutrition course,
267 40% include it as elective and only 40% as a compulsory course in their undergraduate
268 curricula (41). Also, in Greece there is no specialization in renal nursing and in order to
269 be considered a specialized renal nurse one has to have practical training in hemodialysis
270 units for at least 6 months whereas no theoretical courses are required. This could change
271 in the following years since a postgraduate course in renal patient care led by one of the
272 researchers of the study which is mainly addressed to nurses has recently commenced.

273 This was the first study to assess nephrologists' along with renal nurses' and hemodialysis
274 patients' renal nutrition knowledge. Our results are limited by the small number of
275 participants and would require larger scale studies to be further confirmed. We could not
276 perform correlation analysis between patient and nephrologists' knowledge scores due to
277 the small number of nephrologists completing the CKDKAT-N questionnaire, however
278 the better phosphorus knowledge scores of the patients of Unit 3 could be partially
279 attributed to the higher total and phosphorus knowledge scores of the nephrologists of the
280 same unit compared with Unit 1 counterparts (21.4 and 12.4 vs 17 and 8.8 respectively).

281 Low level of phosphorus knowledge among hemodialysis health care staff, could
282 negative affect patients adherence to phosphorus guidelines and jeopardize their overall
283 health. Renal dietitians should be a part of every hemodialysis unit or at least routinely
284 visit units for nutritional assessments and patient training. Along with dietitians,

285 nephrologists and nurses should take part in continuing education programs on nutrition
286 in order to better care for patients dealing with one of the most deliberating diseases.

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289

290 **Statement of Authorship**

291 ZP acquired data, did data analysis, drafted the first version and finalized the final
292 version. MM designed the study, facilitated data collection, did data analysis, reviewed
293 various drafts and finalized the final draft; CDG designed the study, acquired data, did
294 data analysis, reviewed and finalized the final version. CK designed the study, supervised
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297 finalized the final version. TE facilitated data collection, participated in data analysis,
298 reviewed various versions and finalized the final draft. IS designed the study, acquired
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300 study, supervised ZP for data analysis, reviewed the various versions and finalized the
301 final version

302 The manuscript has been read and its submission has been approved by all co –authors

303

304 **Conflict of Interest**

305 The authors declare to have no conflicts of interest related to this manuscript.

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435

436 **FIGURE LEGENDS**

437 **Figure 1.** Percentage of correct answers to questions regarding the knowledge of
438 phosphorus and other nutrients for hemodialysis patients and renal nurses in all tree
439 studies using CKDKAT-N questionnaire (Data from Pollock and Jaffery (2007) and
440 Cupisti et al (2012) extrapolated from text and graphs. No standard deviations are
441 provided in the Pollock and Jaffery (2007) study regarding phosphorus and sodium,
442 potassium and protein knowledge scores.

443

444 **Table 1. Patient characteristics**

	Unit 1	Unit 2	Unit 3	Total
Age, yrs (N=68)	54.8 ± 13.2	55.4 ± 13.8	48.3 ± 15.4	52.5 ± 14.4
Dry weight, kg (N=68)	68.0 ± 12.1	73.0 ± 11.5	69.2 ± 12.0	69.9 ± 11.9
BMI (N=68)	24.4 ± 4.1	24.3 ± 4.1	24.3 ± 4.2	24.4 ± 4.1
Years in hemodialysis, yrs (N=68)	7.9 ± 6.8**	3.5 ± 2.5	6.6 ± 6.1*	6.2 ± 5.8
Serum albumin, g/dL (N=68)	4.1 ± 0.3**	4.1 ± 0.3*	4.4 ± 0.2	4.2 ± 0.3
Serum phosphorus, mg/dL, (N= 49)	5.2. ± 1.5	–	5.6. ± 1.4	5.4. ± 1.5
Ca x P, mg ² /dL ² , (N= 49)	49.2 ± 14.6	–	50.1 ± 12.2	49.7 ± 13.2

445 * P<0.05, ** P<0.01

446 Data are presented as mean ± SD.

447 Abbreviations: BMI: Body mass index, Ca x P: Calcium x phosphorus product.

448

449 **Table 2. Nutrition knowledge scores according to CKDKAT-N**

	Patients	Renal nurses	Nephrologists
N	68	19	11
Total score (max=25)	13.2 ± 2.8 **	14.1 ± 2.8**	19.1 ± 3.6
Phosphorus score (max=15)	7.3 ± 2.0**	7.6 ± 2.2**	10.6 ± 2.7
Rest score (max=10)	6.0 ± 1.4**	6.4 ± 1.5**	8.5 ± 1.6
Sodium questions score (max=6)	4.2 ± 1.0**	4.3 ± 0.9 *	5.3 ± 0.9
Protein questions score (max= 2)	0.7 ± 0.5** [†]	1.2 ± 0.8*	1.7 ± 0.5
Potassium questions score (max=2)	1.1 ± 0.6	0.9 ± 0.7	1.5 ± 0.7
% correct answers in dietary K recommendations question	31%	42%	55%
% correct answers in dietary Na recommendations question	25%**	47%	73%
% of correct answers in dietary P recommendations question	31%*	37%	73%
% of correct answers in all three K, Na and P dietary recommendations questions	0%**	11%**	27%
% of false answers in all three dietary K, Na, and P recommendations questions	28%**	26%**	0%
% of correct answers in desired serum phosphorus level question	72%	63%	100%

450 * P<0.05 from Nephrologists, **P<0.01 from Nephrologists, † P<0.01 from Renal nurses

451 Data are presented as mean \pm SD.

452

ACCEPTED MANUSCRIPT

453 **Table 3. Pearson correlation coefficients for total, phosphorus and rest nutritional knowledge scores in hemodialysis patients,**
 454 **renal nurses and nephrologists**

	N	Total vs Phosphorus	Phosphorus vs Rest
Patients	68	0.868*	0.33*
Renal nurses	19	0.86*	non significant
Nephrologists	11	0.97*	0.85*
All	98	0.91*	0.49*

455 *P<0.01

456 Data are presented as mean \pm SD.

Statement of Authorship

ZP acquired data, did data analysis, drafted the first version and finalized the final version. MM designed the study, facilitated data collection, did data analysis, reviewed various drafts and finalized the final draft. CDG designed the study, acquired data, did data analysis, reviewed and finalized the final version. CK designed the study, supervised ZP for data analysis, reviewed various versions and finalized the final version. VL facilitated data collection, participated in data analysis, reviewed various versions and finalized the final version. TE facilitated data collection, participated in data analysis, reviewed various versions and finalized the final draft. IS designed the study, acquired ethical approval, supervised data analysis and finalized the final draft. GKS designed the study, supervised ZP for data analysis, reviewed the various versions and finalized the final version.

The manuscript has been read and its submission has been approved by all co – authors