Design and psychometric validation of a social capital questionnaire for adults with end-stage chronic kidney disease undergoing dialysis or hemodialysis

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Abstract

Background The effects of end-stage kidney disease (ESKD) can spill over into a patient's social life. Social capital (SC) is a determinant of health that can enhance patients' health through support and resources. However, no questionnaire is currently available to measure SC in ESKD patients. This study aimed to design and validate a questionnaire to measure SC in ESKD adults undergoing dialysis or hemodialysis.

Methods A mixed methods approach was used to generate the questionnaire and determine its content validity with a panel of nine experts and content validity index, face validity through cognitive interviews with patients, construct validity (exploratory and confirmatory factor analysis), criterion validity, reliability and the effect of known groups differences.

Results Content validity was confirmed by an expert panel, achieving a content validity index value > 0.85 for all items. Face validity was achieved through cognitive interviews with 20 patients over 18 years of age in a terminal stage of CKD, ensuring that the target population understood the questions. An exploratory factor analysis used the sample of 610 patients and tested the structure of the seven dimensions of the structural domain (participation in organizations, links to institutions, social network sizes, collective activities, diversity, bridging, and bonding) and explained 95.7% of the total variance with a reliability of 0.89, and criterion validity > 0.32 ($p < 0.05$) for the correlations between the indices of each dimension and the domain index. The structure of the cognitive domain was tested for six dimensions (norms of reciprocity, social harmony, feeling of belonging, perceived fairness, social support, and social trust) with a total variance of 80.7%, reliability of 0.94 and criterion validity for correlations > 0.68 ($p < 0.05$). The confirmatory factor analysis with 352 patients proved the factorial structure adequate for both questionnaire domains and all dimensions, with CFI and TLI values > 0.9, an RMSEA ≤ 0.06, and SRMR ≤ 0.05.

Conclusions We conclude that the questionnaire designed to measure social capital is valid and reliable for ESKD patients in Mexico.

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Introduction

Chronic Kidney Disease (CKD) is a worldwide public health problem that has become a leading cause of death, with an estimated prevalence of 9.1% [1]. The global incidence of end-stage kidney disease (ESKD) is 146 individuals per million population (pmp) per year. The highest incidence of ESKD can be found in Mexico, especially in the states of Jalisco and Aguascalientes, where the incidence reaches 603 cases pmp [2]. In this terminal stage of CKD, the kidney's function has deteriorated significantly, to the extent that it fails to function adequately. As a result, these individuals require dialysis or a transplant to survive, producing important physical, psychological, and social changes in their life [3, 4].

Social determinants of health (SDH) refer to the conditions people are exposed to from birth, influencing their health status [5, 6]. When favorable, these factors can improve an individuals' health even when they only directly influence their social circles [7–9]. In patients with ESKD, adverse SDH may be related to poor access to therapies and a disparity in mortality [10–12]. Social deficiencies may be associated with a loss of independence, a worse quality of life, and poorer social interactions and relationships augmenting the likelihood of social isolation among patients [7, 13, 14].

The World Health Organization considers social capital (SC) to be an intermediate SDH [5], and it has been defined as the "features of social organization, such as networks, norms, and social trust that facilitate coordination and cooperation for mutual benefit" [15]. Belonging to a social group can benefit its members, which is why SC is considered a group property [16]. Indeed, greater SC can improve health outcome. For instance, it can help reduce the progression of CKD in its earlier stages, enhance adherence to treatment regimens, and decrease depression and anxiety in ESKD patients on dialysis [10, 12–14]. Group behavior is one possible mechanism through which such improvement is achieved, as this group phenomenon can influence an individual's behavior [17, 18]. Informal social control is another mechanism that drives behavior according to the rules of the group, ultimately promoting collective action such that participation in a group is promoted to attain mutual benefits [17]. These mechanisms allow bonds to be created that enhance emotional support within social groups, promote health-enhancing behaviors, and facilitate access to resources and/or information [19, 20].

SC has been studied from various theoretical approaches, and it was first addressed through an ego-centered network approach [21]. The study of SC was later extended to the community level [22] and from there, the study of networks, norms and trust was included, in addition to the importance of bonding and bridging as social ties [15]. To facilitate the study of SC, two domains were proposed for its measurement [23]. The first domain is structural, referring to social organization and what people do within their social groups to facilitate cooperation and collective action. The second domain is cognitive, and it refers to what people believe and perceive about their membership of social groups, predisposing them to collaboration and mutual cooperation. Subsequently, two theoretical approaches to SC were described, the first of which is a network approach based on the structural connections an individual has that can provide them with resources and opportunities. The second approach involves cohesion, considered to be an attribute of social groups that contributes to the achievement of common goals [18].

There are a variety of generic scales to measure SC, particularly those that divide SC into its cognitive and structural domains, such as the Adapted SC Assessment Tool (ASCAT) [24, 25], the Family SC questionnaire (FSCQ) [26], and the Bridging SC questionnaire (BSCQ) [27]. However, some scales measure SC without separating it into domains, such as the SC Questionnaire (SCQ) [28], the SC Questionnaire for adolescent students (SCQ-AS) [29], the Global SC Scale (GSCS) [30], the SC and Cohesion Scale (SCCS) [31] and the Integrated Questionnaire to measure SC (SC-IQ) [32]. Other studies have considered that SC can also be measured through the bridging domains, for example with the BSCQ [27], or through the bonding and bridging domains, as with the Personal Social Capital Scale (PSCS) [33]. These and the other scales measure SC with a different scope, taking specific theoretical approaches and having been validated to a different extent [34, 35]. To our knowledge, no instrument has yet been designed and validated to measure SC in adults with ESKD who are undergoing renal replacement therapy (dialysis or hemodialysis). Moreover, multiple studies have highlighted how the measurement of SC depends on the specific problem individuals face and their goals, and it must reflect the social characteristics of the population and the context in which SC will be studied [18, 24, 25, 28, 36, 37].

Given the diversity of scales to measure SC, their different degrees of validation, and the need to have valid and reliable scales to measure SC in the context of specific populations, here we set out to design and validate a questionnaire that measures SC in Mexican patients with ESKD suitable for renal replacement therapy.

Materials and methods

The questionnaire was designed in 7 stages using a mixed methods approach: (1) generation of the items in the questionnaire, (2) content validation, (3) testing of face validity, (4) construct validity (exploratory and confirmatory factor analysis), (5) criterion validity, (6) reliability, and (7) known groups differences. (Fig. 1). The first author led the design and validation of the questionnaire.

Stage 1: generation of the items in the questionnaire

A literature review was conducted to operationalize the concept of social capital using a deductive approach, which moves from broad ideas to specific details. We first employed Putnam's framework to define social capital as a collective attribute. To measure social capital, we integrated Uphoff's structural and cognitive domains. In the structural domain, we included the dimensions: (1) Participation in organizations, (2) Links to Institutions, (3) Frequency of action, (4) Size of networks, (5) Collective actions, (6) Degree of citizenship, (7) Diversity, (8) Bridging, and (9) Bonding. In the cognitive domain, we included the dimensions of (1) Norms of reciprocity, (2) Social harmony, (3) Sense of belonging, (4) Perceived fairness, (5) Social support, and (6) Social trust. In addition, we included in the questionnaire a section that assesses the individuals' participation in 15 social groups, including family, friends, and neighbors, among others, as well as nine dimensions within the structural domain and six dimensions within the cognitive domain.

We then developed questions that ensured their theoretical alignment with the respective dimensions and domains. The responses to the questions were recorded on a 5-point Likert-type scale, with the options ranging from "strongly agree" to "strongly disagree", "very often" to "never", or "fully sufficient" to "totally insufficient".

Stage 2: content validation

Content validation ensures theoretical congruence between the constructs being assessed, the domains, the dimensions, and each question in the questionnaire [38]. As such, the first version of the questionnaire was evaluated by nine experts following a Delphi approach. These experts included two psychologists, a sociologist, a nephrologist, a nurse specializing in nephrology, two public health specialists with experience in the study of SC, and two family physicians. Each of the experts was sent an e-mail invitation to participate, which was accompanied by an outline of the theoretical framework
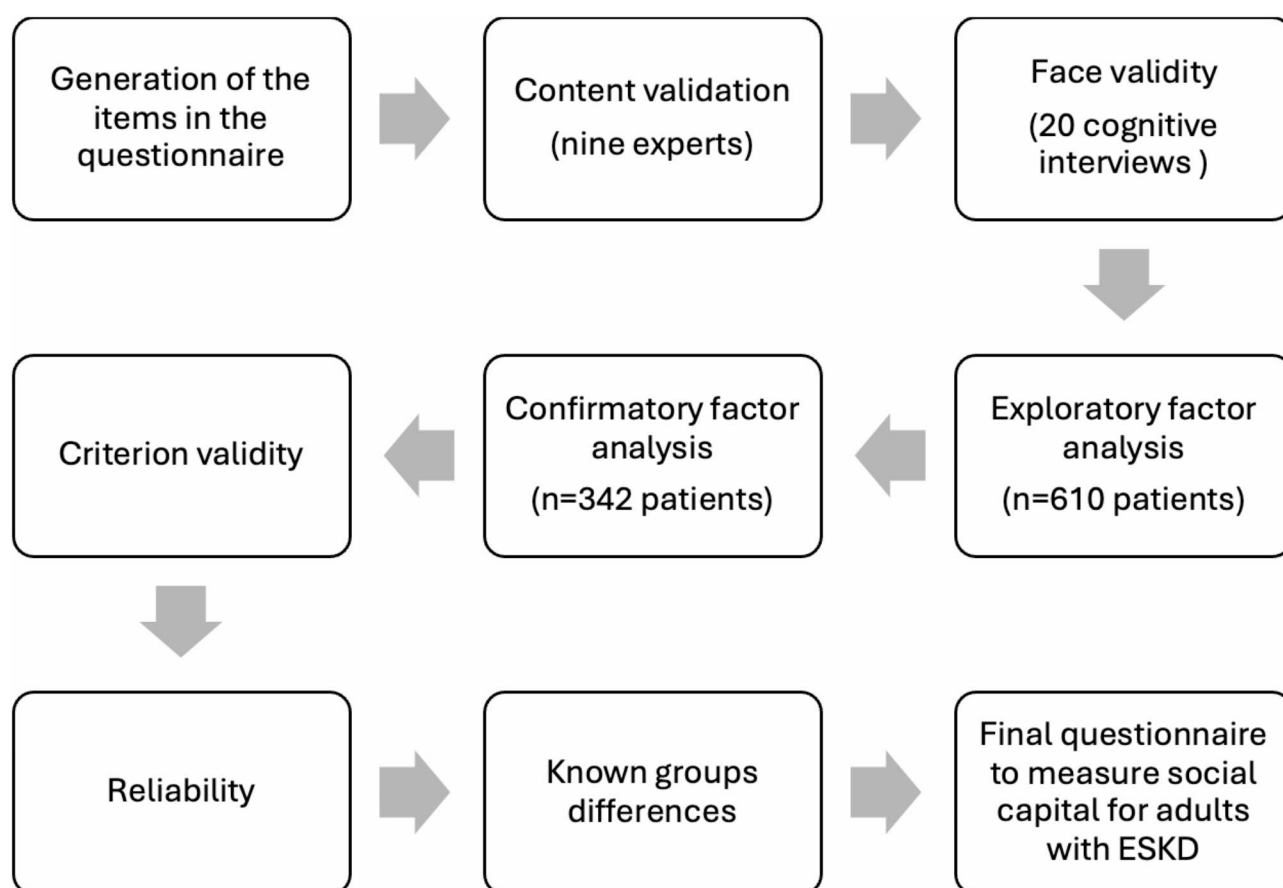

Fig. 1 Flow chart of the design and validation of a social capital questionnaire for ESKD patients. Abbreviation: ESKD: End-stage chronic kidney disease

underlying the design of the questionnaire, the operationalization of the SC and a form to evaluate the content of the questionnaire according to its relevance, the latter enabling comments to be introduced. The content was validated quantitatively using the Lawshe content validity index (CVI) modified by Tristan, which assesses the consensus of the experts based on the formula $CVI = ne/N$, where ne = number of experts who agree with the question, rating it as "pertinent", and N = the total number of experts, estimating this index for each question. A $CVI > 0.58$ was considered the threshold to define the relevance of each question [39].

Stage 3: face validity

The face validity of the questionnaire was assessed through 20 cognitive interviews of patients over 18 years of age in a terminal stage of CKD. These interviews were conducted by the first author of the article, who has a Master of Science degree, previous experience in scale validation and is currently a student in a Doctor of Science program. The interviews lasted approximately one hour, and the patients were selected by convenience, trying to include individuals of different ages and levels of schooling. The aim was to assess how well each question and its response options in the questionnaire were understood. This involved identifying items and terms that were unclear, confusing, or misunderstood by the intended audience, to modify these items to enhance their clarity [40].

Stage 4: construct validity

Construct validity was conducted by exploratory and confirmatory factor analysis (EFA and CFA). The sample size for construct validity was estimated at around 10 patients per question of the questionnaire to obtain adequate stability of the factorial structure during the validation process [41]. The patients were selected by simple randomization from the lists of patients over 18 years of age in a terminal stage of ESKD who were undergoing hemodialysis or peritoneal dialysis and attending three nephrology outpatient services in Aguascalientes City: one at the Mexican Institute of Social Security (IMSS) ambulatory care clinic, one at the IMSS General Hospital, and one at the Ministry of Health General Hospital. Selection took place from April to December 2023. The questionnaire was administered to patients during hemodialysis sessions or before or after their appointments in the nephrology outpatient services. Participants were required to be over 18, in the terminal stage of ESKD, and free from cognitive impairments (i.e., any mental disorder accompanied by intellectual or cognitive disabilities, verified through selection criteria questions and information from the patients' clinical records). Signed informed consent was obtained from all patients prior to participation.

Recognizing that recurrent dialysis can reduce blood flow to the central nervous system and affect cognitive function. If patients reported sleepiness, fatigue, or physical discomfort while completing the questionnaire, the process was stopped, and these patients were excluded from the analysis due to incomplete data.

A polychoric correlation matrix was constructed for the EFA, given that the items in the questionnaire are responded through a Likert-type scale [42]. An anti-image correlation matrix was examined to determine whether the partial correlation coefficients were close to zero and whether most of the correlation coefficients were > 0.3 [43]. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was calculated to explore whether the factor analysis was relevant, considering a value > 0.7 adequate [44]. Bartlett's test of sphericity was applied to assess whether the correlation matrix differs from the identity matrix, the acceptable value of which should be $p < 0.05$. The EFA was assessed using principal axis factoring due to the Likert-type scales used to respond to the items in the questionnaire [45]. To simplify the factor structure, an oblique promax rotation was performed [45]. Since we already know the number of dimensions (factors) in each domain, the EFA aimed to check the number and composition of the factors through the common variance (communalities) and factor loadings [44]. Several models were assessed to find that with the most parsimonious structure. The criteria applied to determine the relevance of each of the factors was an eigenvalue > 0.7 [46], and each factor had three or more questions. The criteria used to define the relevance of the items in the questionnaire, and hence whether or not they were retained, were: (1) a communality value > 0.3, (2) having factor loadings > 0.35; and (3) grouping of each question in only one factor without having cross factor loadings > 0.32 in two or more factors [41, 44, 45].

The CFA was run for each of the dimensions in the questionnaire to confirm the factor structure obtained with the EFA. The comparative fit index (CFI), the Tucker-Lewis index (TLI), the root mean square error of approximation (RMSEA), and the square root of the standardized mean residual (SRMR) were used to assess the quality of the model fit. Models with a $CFI > 0.90$, $TLI > 0.90$, $RMSEA < 0.06$ and $SRMR < 0.08$ were considered a good fit [47].

Stage 5: criterion validity

Criterion validity was performed to evaluate whether the content of the questionnaire adequately correlates with the chosen criterion, using the indices of the structural and cognitive domains [45]. These indices were constructed by summing up all the questions retained in each domain of the final questionnaire and comparing them with the sum of the questions in each dimension

[45]. The criterion validity was evaluated using the Spearman correlation coefficient [45].

Stage 6: reliability

The reliability of the questionnaire was calculated based on the Cronbach's alpha value for each dimension and for each domain [48].

Stage 7: differentiation by known groups

The analysis of known groups differences was performed to examine whether employing the questionnaire on groups defined by age, sex, or education produced distinct results. According to the literature, it was hypothesized that there would be a difference in the SC between the different age groups 18–34, 35–49, 50–64, and > 65 years of age [49, 50] and between men and women [51]. This hypothesis was based on data from the literature, and it assumes that the closeness/contact with other people and network size decreases with age, whereas trust in co-workers tends to increase [49]. In addition, it was found that SC increases with age in women of reproductive age 15–49 years of age [50], and that men tend to have higher levels of instrumental SC while women tend to be stronger in the social-emotional dimensions [51]. Regarding education, a higher educational level is expected to be associated with greater SC [52].

The statistical analysis was performed with STATA version 18 StataCorp LLC, College Station, TX, USA.

Results

Generation of the items in the questionnaire

A bank of 62 questions for the structural domain and 46 for the cognitive domain, with 6 to 10 questions per dimension were selected. The items were those we considered would enable to obtain the information that will help understand what SC is like in patients with ESKD.

Content validation

Two rounds of evaluation were performed by the experts. During the first round, the experts suggested eliminating the "Frequency of action" dimension due to its similarity to the "Collective actions" dimension. Three items were removed from the questionnaire due to their poor theoretical congruence: one from the dimension of "Norms of reciprocity", another from "Sense of belonging" and another from "Social trust". A further 6 questions were added to better evaluate the dimensions of "Participation in organizations", "Collective actions", "Perceived fairness" and "Social trust". In addition, the experts made suggestions regarding 61 questions in order to make them clearer. For 11 items, the CVI was < 0.58, and thus, they were modified and further evaluated in the next round.

In the second round, one item was eliminated from the "Social support" dimension because of its similarity

to another in that dimension. Suggestions were made regarding nine items in the dimensions of "Participation in organizations", "Collective actions", "Degree of citizenship", "Norms of reciprocity" and "Perceived fairness" in order to make them clearer. Finally, it was suggested that a question be added in the "Participation in organizations" dimension and another in the "bridging" dimensions. The CVI was > 0.85 for all items.

Face validity

Twenty cognitive interviews were carried out, in four blocks of five interviews. The general characteristics of the patents involved in face validity are shown in Supplementary Table 1. Half of the participants were male; the majority were either married or in a civil union with a life partner (65%), had completed secondary (40%) or primary (35%) education, were engaged in housekeeping (45%), or paid jobs (30%). In the first two blocks of the interviews, patients indicated that some phrases were unclear in seven questions, which were then edited to make them clearer. Difficulties were also seen in answering the questions related to the dimension of "Participation in organizations" and consequently, the responses were changed from "strongly agree to strongly disagree" to "very often to never". After making these modifications, the third and fourth blocks of interviews were conducted to ensure an adequate understanding of all the questions.

Construct validity, criterion validity, and reliability of SC questionnaire

For this stage of the study, we obtained two different patient samples: 610 patients for the EFA and 352 patients for CFA. We excluded 17 patients from the analysis (1.7%) because they reported fatigue, sleepiness, or physical discomfort that prevented them from completing the questionnaire.

Table 1 outlines the general characteristics of the patients involved in EFA and CFA of the SC questionnaire. Most of participants were male. The most frequent characteristics among the study population were being married, having a secondary school education, and being employed. The most common comorbidity was hypertension, and the primary treatment modality for renal replacement therapy was hemodialysis.

SC structural domain

The KMO index for the items in the structural domain was 0.88, and Bartlett's sphericity obtained a $p < 0.0001$, suggesting the relevance of the EFA. The EFA indicated that 33 questions had to be eliminated because they did not meet the criteria for relevance. None of the questions within the "Degree of citizenship" dimension met the criteria, so this dimension was eliminated. The EFA

Table 1 Characteristics of the participants

Characteristics	EFA (n = 610)	CFA (n = 352)	
	n (%)	n (%)	p
Age, in years, median (minimum-maximum)	40 (18–86)	42 (20–85)	0.56
Sex			
Male	342 (56.1)	214 (60.8)	0.15
Female	268 (43.9)	138 (39.2)	
Civil Status			
Married/Civil Union	383 (62.8)	221 (62.8)	0.56
Single	177 (29.0)	92 (26.1)	
Divorced/Widowed	50 (8.2)	39 (11.1)	
Education			
No formal education or incomplete primary education	83 (13.6)	47 (13.3)	0.12
Primary education completed	117 (19.2)	61 (17.3)	
Secondary education completed	207 (33.9)	147 (41.8)	
High school	136 (22.3)	63 (17.9)	
University studies with or without post-graduate degrees	67 (11)	34 (9.7)	
Employment			
Employed	205 (33.5)	119 (33.8)	0.13
Housewife/husband	173 (28.4)	89 (25.3)	
Pensioner	151 (24.8)	98 (27.8)	
Unemployed	81 (13.2)	46 (13.1)	
Comorbidities			
Diabetes	202 (33.1)	126 (57)	0.4
Hypertension	218 (35.7)	280 (89.7)	
Kidney Replacement Therapy			
Hemodialysis	540 (86.0)	272 (77.3)	0.08
Peritoneal Dialysis	70 (14.0)	80 (22.7)	

EFA, Exploratory Factor Analysis. CFA, Confirmatory Factor Analysis

p, level of significance < 0.05

confirmed the factor structure of seven dimensions in the structural domain with a total of 28 out of 61 questions. Each dimension had at least three questions. This model explained 95.7% of the variance of the structural domain (Table 2). The criterion validity showed significant correlations between the index of the structural domain and the index of each dimension. When the reliability of the structural domain was assessed, the Cronbach's alpha of 0.89 reflected an adequate internal consistency (Table 2).

The CFA revealed a good fit for each dimension of the structural domain: "Participation in organizations" had a CFI 0.99, TLI 0.97, RMSEA 0.05 and SRMR 0.03; "Links to institutions" a CFI 0.95, TLI 0.93, RMSEA 0.06 and SRMR 0.04; "Size of networks" a CFI 0.99, TLI 0.99, RMSEA 0.06 and SRMR 0.02; "Collective actions" a CFI 0. 98, TLI 0.97, RMSEA 0.06 and SRMR 0.04; "Diversity" a CFI 0.99, TLI 0.97, RMSEA 0.06 and SRMR 0.04; "bridging" CFI 0.99, TLI 0.96, RMSEA 0.06 and SRMR 0.02; "bonding" CFI 1, TLI 1, RMSEA 0.00 and SRMR 0.004. The goodness-of-fit indices of the final model

obtained through the CFA included 28 questions within seven dimensions with a CFI of 0.92, TLI of 0.90, RMSEA of 0.06, and SRMR of 0.08 (Fig. 2).

SC cognitive domain

The KMO index calculated for the items in the cognitive domain was 0.94 and Bartlett's sphericity gave a $p < 0.001$, highlighting the relevance of the EFA. The EFA indicated that seven questions had to be eliminated because they did not meet the criteria of relevance. The EFA assessed the factor structure of six dimensions of the cognitive domain, with a total of 38 questions. The final cognitive domain model explained 80.7% of the variance (Table 3). The criterion validity showed significant correlations between the index of the cognitive domain and the index of each of the dimensions. The reliability of the cognitive domain showed adequate internal consistency with Cronbach's alpha of 0.94. (Table 3).

The CFA revealed a good fit for each dimension of the cognitive domain: "Norms of reciprocity" had a CFI 0.99, TLI 0.98, RMSEA 0.07 and SRMR 0.021; "Social harmony" a CFI 0.99, TLI 0.99, RMSEA 0.04 and SRMR 0.02; "Sense of belonging" a CFI 0.99, TLI 0.99, RMSEA 0.06 and SRMR 0.02; "Perceived fairness" a CFI 0.99, TLI 0.99, RMSEA 0.05 and SRMR 0.02; "Social support" a CFI 0.99, TLI 0.97, RMSEA 0.09 and SRMR 0.02, "Social trust" a CFI 0.99, TLI 0.99, RMSEA 0.017 and SRMR 0.03. The goodness-of-fit indices of the final model obtained in the CFA were adequate, with a CFI of 0.94, TLI of 0.93, RMSEA of 0.06, and SRMR of 0.05 (Fig. 3).

Differentiation of the known groups differences

The analysis of known groups differences in the structural and cognitive domains showed no differences in the SC between men and women, yet there were differences between the age groups in both these domains, with a higher SC in younger patients (Table 4). Patients who completed high school or university showed a higher level of structural SC. Additionally, patients undergoing peritoneal dialysis included a greater proportion of those with low and medium levels of structural and cognitive SC, whereas patients on hemodialysis had a higher proportion of cognitive SC levels.

The final validated version of the Spanish version of the SC questionnaire for ESKD patients is presented in Additional file 1. Completing this version of the questionnaire takes an average of 23 min. We also included its English translation by an authorized interpreter (Additional file 2). However, it is important to note that English version of the questionnaire requires psychometric validation within the English-speaking population before its use.

Alanis-Ocádiz *et al. BMC Nephrology*   (2025) 26:105

Page 7 of 12

Table 2 Final model of the EFA for the structural domain, reliability and correlation coefficient

DIMENSIONS / Item number	Factor 1	2	3	4	5	6	7	Communalities	Cronbachs' Alpha	Correlation coefficient
Participation in organizations									0.86	0.59*
PO1						0.8569		0.7391		
PO2						0.8991		0.8047		
PO3						0.7699		0.6889		
Links to institutions									0.65	0.32*
LI8							0.7642	0.5892		
LI9							0.7414	0.6059		
LI10							0.7791	0.6972		
Network sizes									0.86	0.75*
NS1	0.8301							0.6900		
NS2	0.8305							0.7272		
NS3	0.7704							0.6780		
NS4	0.6965							0.5742		
NS5	0.6894							0.5749		
NS6	0.5834							0.5316		
Collective Actions									0.88	0.69*
CA3			0.6940					0.6036		
CA4			0.9001					0.8507		
CA5			0.8795					0.8281		
Diversity									0.86	0.62*
D4		0.6625						0.5320		
D5		0.9008						0.8428		
D6		0.8951						0.8156		
D7		0.7357						0.6134		
Bridging									0.78	0.37*
BR2					0.7121			0.6036		
BR3					0.8494			0.6780		
BR4					0.8547			0.7835		
BR5					0.6113			0.5621		
BR6					0.8049			0.7135		
Bonding									0.79	0.68*
BO2				0.7138				0.5386		
BO3				0.7050				0.6321		
BO4				0.7596				0.7365		
BO5				0.7413				0.7799		
Total of the dimensions									0.89	

EFA: Exploratory Factor Analysis

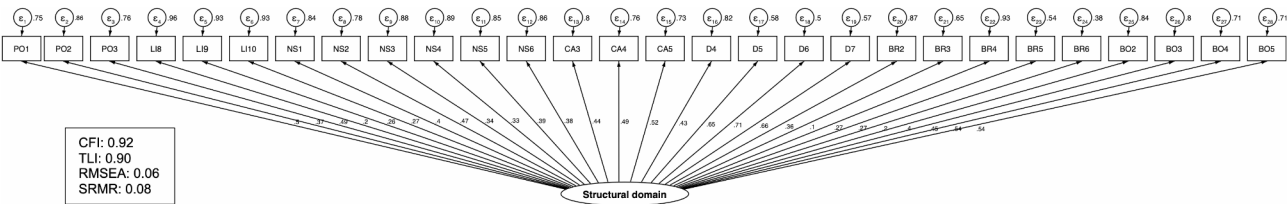[i] Spearman's correlation coefficient: *$p < 0.001$*

Fig. 2 Confirmatory factor analysis of the structural domain. Abbreviations: PO: participation in organizations, IL: links to institutions, NS: Network sizes, CA: Collective Actions: D: diversity, BR: bridging, BO bonding. ε: variance error

Table 3 Final model of the EFA for the cognitive domain, reliability and correlation coefficient

DIMENSIONS	Factor						Communalities	Cronbachs' Alpha	Correlation coefficient
Item number	1	2	3	4	5	6			
Norms of reciprocity									
NR1	0.9463						0.8231	0.93	0.72*
NR2	0.9439						0.8632		
NR3	0.8810						0.8277		
NR4	0.8639						0.8776		
NR5	0.8008						0.7742		
NR6	0.8779						0.8085		
NR7	0.8450						0.8229		
NR8	0.5881						0.7470		
Social Harmony									
SH4						0.5293	0.7193	0.72	0.70*
SH5						0.6854	0.7314		
SH7						0.7036	0.6534		
Sense of Belonging									
SB1		0.6930					0.8177	0.90	0.77*
SB3		0.6520					0.6402		
SB4		0.7764					0.7900		
SB5		0.8620					0.8872		
SB6		0.8154					0.8518		
Sense of Fairness									
SF1				0.6908			0.7608	0.92	0.68*
SF2				0.7590			0.709		
SF3				0.8058			0.8716		
SF4				0.7963			0.8300		
SF5				0.8970			0.8520		
SF6				0.9281			0.8364		
SF7				0.8499			0.6600		
SF8				0.8454			0.6585		
Social Support									
SS1			0.4993				0.6552	0.88	0.79*
SS2			0.7448				0.6957		
SS3			0.7531				0.7846		
SS4			0.8351				0.8753		
SS5			0.8997				0.8892		
SS6			0.6637				0.5644		
Social Trust									
ST1		0.8706					0.6376	0.84	0.80*
ST2		0.6838					0.5748		
ST3		0.5404					0.7240		
ST4		0.7069					0.6353		
ST5		0.5871					0.6482		
ST6		0.5370					0.6350		
ST7		0.5956					0.5880		
ST8		0.6089					0.5366		
Total of the dimensions								0.94	

EFA: Exploratory Factor Analysis

[i] Spearman's correlation coefficient: *$p < 0.001$

Discussion

In this study, we designed and validated a questionnaire to measure SC in patients with ESKD in Mexico, demonstrating its robust psychometric properties.

The initial version of the questionnaire consisted of 108 items, with more than six questions in each dimension. This was proposed based on recommendations in literature to create up to five times the number of questions
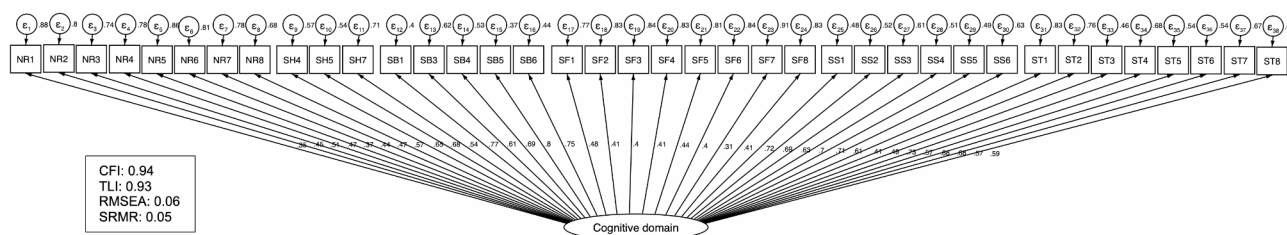
Fig. 3 Confirmatory factor analysis of the cognitive domain. Abbreviations: NR: Norms of reciprocity, SH: Social harmony, SB: Sense of belonging, SF: Sense of fairness, SS: Social support, ST: Social trust. ε: variance error

Table 4 Analysis of the known group differences (*n* = 610)

Variables	Level of Structural Social Capital				Level of Cognitive Social Capital			
	Low ≤ 65 (*n* = 213)	Medium 66–79 (*n* = 208)	High > 80 (*n* = 189)	*p*	Low ≤ 146 (*n* = 215)	Medium 147–167 (*n* = 198)	High ≥ 168 (*n* = 197)	*p*
Sex (%)				0.29				0.67
Male	32.46	36.26	31.29		34.21	33.92	31.87	
Female	38.06	31.34	30.60		36.57	30.60	32.84	
Age (in years)				< 0.001*				0.004*
18 to 34	29.26	31.88	38.86		30.57	33.62	35.81	
35 to 49	32.17	30.77	37.06		30.07	27.97	41.96	
50 to 64	40.51	40.51	18.99		42.41	33.54	24.05	
> 65	45.0	33.75	21.25		43.75	35.00	21.25	
Education				0.03*				0.42
No formal education or incomplete primary education	45.78	36.14	18.07		48.19	26.51	25.30	
Primary education completed	41.03	31.62	27.35		35.90	30.77	33.33	
Secondary education completed	33.33	36.71	29.95		30.92	36.71	32.37	
High school	27.94	33.82	38.24		36.03	30.15	33.82	
University studies	26.79	28.57	44.64		28.57	33.93	37.50	
Post-graduate degrees	45.45	27.27	27.27		36.36	36.36	27.27	
Kidney Replacement Therapy				0.03*				0.001*
Hemodialysis	37.0	32.0	31.0		32.0	33.2	34.8	
Peritoneal Dialysis	25.5	43.6	30.9		50.0	29.1	20.9	

*p level of significance < 0.05

than it is expected to have in the final version, such that the elimination of any of these during the validation process does not have a negative impact [45]. For example, during the content validity, the "Frequency of action" dimension was eliminated because the expert panel considered that the "Collective actions" dimension measures both the frequency of the patients' actions as well as the actions themselves. The elimination or modification of dimensions and/or of questions of little relevance or theoretical congruence with the construct being measured also occurred elsewhere [26, 27, 29, 33, 53–55].

The face validity of the questionnaire was evaluated through cognitive interviews, as in previous studies [25, 55] and different from the other approaches, such as the pilot tests [32, 37, 56]; or focus groups [26, 29]. Cognitive interviews have the advantage of exploring people's cognitive process to understand the questions, identifying unfamiliarity or confusion with some words or syntax,

and defining appropriate responses [40, 45]. The modifications made in light of the cognitive interviews ensured that patients with ESKD of different ages and education readily understood the questions and possible responses of the SC questionnaire.

In terms of the construct validity, the number of questions of the SC questionnaire reduced considerably from 106 to 66 [57, 58]. All the questions had acceptable factor loadings > 0.5 [43], which reflects the contribution of each question to the factor to which it belongs: the higher its value, the stronger its contribution [46]. Indeed, these data coincide with those published earlier regarding a questionnaire for which the questions in the final model had factor loadings > 0.4 [56].

The communalities of the questions were all greater than 0.5, which is considered an adequate value [59]. In the EFA, the value of communalities is important because it explains the amount of variance that a question has in

common with all the others in the same dimension [59]. Previously, communalities greater than 0.5 were only found for items used to measure family SC [26] with other questionnaires showing communalities > 0.3 [60], > 0.38 [61] or > 0.46 [29]. By eliminating the questions that did not meet the established criteria, the value of the total variance of the final models of the structural and cognitive domains turned out to be adequate [57, 58], and higher than that validated with an EFA in other questionnaires to measure SC. The proportion of the total variance explained elsewhere ranged from 41.11% [37] to 47.8% [30], 52.77% [61] and 59% [53]. In this study, the total variance reached 95.7% in the structural domain and 80.7% in the cognitive domain.

Regarding the criterion validity, all values obtained were significant relative to the index for each dimension with the structural domain index or the cognitive domain index of the SC questionnaire. In this regard, a previous evaluation of the correlation between the questionnaire's dimensions also obtained significant results, with correlations > 0.2 [56].

Our questionnaire demonstrated good internal consistency with a score of > 0.70 in the structural and cognitive domains [48]. The only exception was the dimension of "Links to institutions" that obtained a value of 0.65. This value indicates that the consistency of the responses is limited in this dimension, such that further studies may be needed to improve the reliability of this dimension. In a similar study conducted in Greece, the SC questionnaire also showed some dimensions with Cronbach's alpha values < 0.70 (0.33 and 0.68) [37]. However, other scales used to measure SC have shown average Cronbach's alpha values of 0.80 [27, 31, 37, 53, 60–62].

The CFA confirmed the validity of the theoretical models for the structural and cognitive domains through an adequate goodness-of-fit. In the "Social support" dimension, the RMSEA value was 0.09, while the CFI, TLI and SRMR showed an excellent fit in this dimension. The high RMSEA value in this dimension may be due to the presence of multiple response options. Therefore, it is recommended to use the SRMR value as it provides greater precision for ordinal variables, thereby giving a more accurate results of the model's fit [63]. Additionally, using more than one goodness-of-fit index is suggested for a CFA to reduce the possibility of bias in the results due to the limitations of each index [47]. Several studies used CFI and TLI, RMSEA and SRMR to evaluate the model fit in the CFA of the SC questionnaires, finding a good fit of the models [26, 30, 33, 53, 54]. However, poor fit was observed in certain dimensions of SC in other studies, highlighting the importance of complementing construct validity with the CFA [27, 61].

In the analysis of known groups, the difference in the SC between age groups may reflect the fact that the closeness/contact with other people and the size of the networks decreases as age advances, with higher levels of SC in younger patients [49]. However, one study reported that in women of reproductive age (15 to 49 years) SC increases with age as they tend to create closer ties over time [50].

Our study has strengths and limitations. Its strengths include a comprehensive literature review based on the theory underlying SC, as reflected in the selection of the domains, dimensions and items of the questionnaire. Moreover, a comprehensive psychometric validation was undertaken with sufficient sample size and focusing on a scale for patients with ESKD for whom there was no previously validated SC scale. Among the limitations, the validation of the scale was performed exclusively on patients with ESKD in Aguascalientes (Mexico) and therefore, it must also be validated in other settings. Moreover, as the scale contains 66 questions, it requires, on average, 23 min to complete, suggesting the need for a future study to develop a short version of this scale.

Conclusions
In conclusion, the SC questionnaire for ESKD patients we have developed has adequate psychometric validity and to our knowledge, it is the first questionnaire suitable to measure SC in Mexican population. Recognizing the importance of quality of life for patients with ESKD, it is essential that future research endeavors examine the relationship between social capital and quality of life, along with other health outcomes, in ESKD patients undergoing dialysis.

Abbreviations
ASCAT	Adapted Social Capital Assessment Tool
BSCQ	Bridging Social Capital questionnaire
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
CKD	Chronic kidney disease
CVI	Content Validity Index
EFA	Exploratory Factor Analysis
ESKD	end-stage kidney disease
FSCQ	Family Social Capital Questionnaire
GSCS	Global Social Capital Scale
IMSS	Mexican Institute of Social Security
PSCS	Personal Social Capital Scale
SC	Social capital
SCCS	Social Capital and Cohesion Scale
SC-IQ	Integrated Questionnaire to measure Social Capital
SCQ	Social Capital Questionnaire
SCQ-AS	Social Capital Questionnaire for adolescent students
SDH	Social determinants of health
SRMR	Square Root of the standardized Mean Residual
RMSEA	Root Mean Square Error of Approximation
TLI	Tucker-Lewis Index

Supplementary Information
The online version contains supplementary material available at https://doi.org/10.1186/s12882-025-03993-9.

Alanis-Ocádiz *et al. BMC Nephrology*   (2025) 26:105

Page 11 of 12

Supplementary Material 1

Supplementary Material 2

Supplementary Material 3

Declarations

Ethics approval and consent to participate
The IMSS National Scientific Research and Ethics Committee approved the research protocol under registration number R-2022-785-053. All patients who participated in the study signed informed consent before being enrolled. The study was conducted in accordance with the Declaration of Helsinki.

Consent for publication
Consent for publication was not required by the IMSS National Scientific Research and Ethics Committee.

Competing interests
The authors declare no competing interests.

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