


Psychometric testing of the hemodialysis self-management instrument (HDSMI-18): A confirmatory factor analysis

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Abstract

Aim: The aim of this study was to probe the rigorousness of the factor structure of the HDSMI and to test the instrument's construct validity.

Design: Cross-sectional study.

Methods: The hemodialysis unit of four hospitals in Taiwan provided data from 628 patients with end-stage renal disease (ESRD), through the period of September to December in 2012. The patients were divided into a calibration sample for CFA and model modification, and a validation sample for cross-validation of the postmodification model. Goodness of fit was tested with standard fit indices.

Results: The four latent variables (i.e. partnership, self-care, problem-solving and emotional management) were verified as dimensions of HDSMI through CFA. The construct validity of the HDSMI was improved by omitting two items, allowing one inter-item correlation and transferring the loading of one item. These modifications improved fit indices of the calibration sample. Cross-validation of the validation sample verified the construct validity of the modified HDSMI-18.

KEYWORDS

confirmatory factor analysis, cross-validation, haemodialysis, self-management

1 | INTRODUCTION

In Taiwan, end-stage renal disease (ESRD) is treated primarily with haemodialysis, with ESRD patients accounting for 90.2% of the total number of dialysis patients (Huang et al., 2015). Without kidney replacement, patients rely on dialysis treatments multiple times each week in order to stay alive. Patients on long-term haemodialysis are at an increased risk of a variety of physical, psychological and social problems. They are prone to physiological symptoms that compromise their quality of life, such as respiratory insufficiency, fatigue,

pain, nausea, vomiting, oedema and pruritus (Almutary et al., 2016; Mohammad, 2019; Siregar et al., 2020). Psychologically, they often suffer from anxiety, depression and various mental health struggles. Feelings of helplessness can stem from the long-term impact of living with an arteriovenous fistula. Furthermore, changes in appearances associated with the diseases can limit employment and economic opportunities (AIDukhayel, 2015; Siregar et al., 2020). Patients may withdraw from social activities, due to body image issues caused by self-consciousness of their arteriovenous fistula (Taylor et al., 2016). In the face of complex health problems, integrating self-management

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behaviours can play a key role in achieving desired health outcomes for patients with ESRD. Through self-management, patients learn to be more involved with their own diseases and shoulder responsibilities in the daily management of their chronic illnesses, through shared decision-making between patients and healthcare providers, performing daily self-care activities, seeking medical resources and using problem-solving skills to resolve health problems (Song & Lin, 2009).

Curtin et al. (2005) divided the self-management of haemodialysis patients into two categories: healthcare self-management and daily life self-management. The former emphasizes disease care, while the latter refers to achieving or maintaining normal daily role functions. In addition to the attention to disease trends and behavioural changes, emotional adjustments and effective communication of symptoms between patients and healthcare providers are part of health care as well (Holman & Lorig, 2004). With regard to the above, the ultimate goal of chronic disease self-management is not only to achieve disease control through healthcare activities, but also for patients to balance daily life with illnesses and maintain a normal life after being ill.

To avoid complex complications resulting from ESRD and dialysis, healthcare providers need to identify possible barriers in illness management by using valid tools. Healthcare providers can then design and implement appropriate strategies to tackle and prevent these barriers, through improving self-management based on the patient's situation (Fort et al., 2013). Consistent and effective self-management practices can help patients deal with complex and dynamic illness conditions (Gela & Mengistu, 2018). In self-management, patients undergoing haemodialysis take the initiative to seek medical resources and engage in medical team discussions. The emotional impact of health problems and disease-related changes to one's body image may be mitigated, to some extent, with proactive problem-solving and daily self-care activities (Griva et al., 2018), which can also improve the patients' overall health and quality of life.

Self-management instruments are used to assess self-management among patients undergoing haemodialysis (Curtin et al., 2004; Song & Lin, 2009), by simplifying the process of identifying behaviour in self-management. The self-management instrument for haemodialysis patients developed by Curtin et al. (2004) has a total of eight dimensions and 37 items. The instrument divided self-management behaviours into: suggestions to providers, self-care during dialysis, information seeking, use of alternative therapies, selective symptom management, assertive self-advocacy, impression management and sharing responsibility in care. It should be noted that self-care in this instrument is limited to self-care activities only during dialysis treatment. However, patients must comply with medical prescriptions, strictly obey dietary restrictions and water control, as well as care for their arteriovenous fistula in daily life, which are all indispensable tasks for everyday disease care that are not included in this instrument. The Cronbach's α value of the assertive self-advocacy subscale was only .65, which did not meet the .70 standard (Burns & Grove, 2004).

Exploratory factor analysis was performed on the 20-item HDSMI to test for validity (Song & Lin, 2009). The results indicated that the structure of the four factors was consistent with the defining attributes, derived from the conceptual analysis of self-management in chronic disease (Song et al., 2008), which suggests that this instrument has good construct validity. The HDSMI has not yet been subjected to confirmatory factor analysis (CFA) to test whether the 20 items correspond to theoretically predicted constructs and how well empirical data fit with theoretical expectations. Therefore, to test the rigour of the HDSMI, CFA was conducted in this study to examine the strength of correlations between the instrument's structural factors and themes, identify changes that may improve its rigour, and test its construct validity in patients with ESRD on haemodialysis.

2 | METHODS

2.1 | Study design, sampling and setting

Upon receiving permission from the HDSMI developers, a cross-sectional study was conducted on haemodialysis patients from one medical centre, one regional teaching hospital and two private dialysis centres in southern Taiwan. Data were collected for a total duration of four months from September–December 2012. Participants were selected through purposive sampling. The inclusion criteria for participants were those aged ≥ 18 years, who had ≥ 6 months of haemodialysis treatment, and who could comprehend and communicate in Mandarin or Taiwanese. Data were collected through questionnaires, which were delivered in person. Trained haemodialysis nurses were present to offer assistance by explaining or clarifying the questions. Valid questionnaires were those that were filled out and completed personally by participants. Questionnaires that were incomplete were deemed invalid and were excluded from the study. Demographic data such as age, marital status, level of education, religion, employment status and length of time (in months) on haemodialysis were recorded. The original HDSMI in Mandarin with 20 items was used to assess the self-management behaviour of patients undergoing haemodialysis.

This research was conducted in two phases. In the first phase, we tested how well the CFA-generated model of the Mandarin HDSMI factor structure fit empirical data, and then modified it accordingly. In the second phase, we cross-validated the modified model with empirical data from a second sample data to verify the HDSMI's factor structure.

2.2 | Ethical considerations

The study protocol was approved by the institutional review boards of a medical centre and a university in Taiwan. Participation was voluntary, and all participants provided written informed consent. The questionnaires were anonymous and confidential.

2.3 | Factors associated with haemodialysis self-management instrument

The original HDSMI in Mandarin developed by Song and Lin (2009) was used to assess the self-management of patients receiving haemodialysis. This instrument contains 20 items, which are divided into four dimensions: Partnership, Self-care, Problem-solving and Emotional management. Cronbach's α coefficients for the HDSMI-20 were found to be .87 for the total scale and to be in the range of .70–.78 for the subscales, explaining 45.13% of the total variance (Song & Lin, 2009). Subjects responded to each item on a 4-point scale: 1, never; 2, rare; 3, sometimes; and 4, always. Total scores ranged from 20–80, with higher scores indicating a higher level of self-management. Based on prior exploratory factor analysis of reliability and validity (Song & Lin, 2009), the instrument has been employed to measure self-management behaviour in patients receiving haemodialysis. In order to test the factor structure of the HDSMI hypothesized model, the construct validity was further tested with confirmatory factor analysis.

2.4 | Psychometric evaluation

2.4.1 | CFA modelling and model modification

CFA of the 20-item HDSMI was conducted with the calibration sample. Measurement theory was used to specify an a priori number of factors and which variables load on those factors (Hair et al., 2010). Multilevel structural equation modelling (SEM) was employed to examine factor loadings. Software supplied model modification tests were employed to estimate how much the χ^2 result would improve if particular fixed parameters were free to be estimated in the model. The model was modified according to the modification index data obtained. Regarding the fitness of the internal structure of model, we set 3.84 as the maximum modification index value (Bagozzi & Yi, 1988). To ensure construct validity and examine its cross-sample stability, our modified model was subjected to cross-validation in the validation sample.

2.4.2 | Goodness of fit

As described previously (Hu & Bentler, 1999; Kamaruzzaman et al., 2010), goodness of fit of the model was determined based on comparative fit index (CFI), Tucker–Lewis index (TLI), standardized root mean residual (SRMR), root mean square error of approximation (RMSEA) values as well as Chi-square (χ^2) and χ^2 /degrees of freedom (*df*) results. The fit was considered good if the following criteria were met: CFI \geq 0.95, TLI $>$ 0.95, SRMR $<$ 0.08, RMSEA \leq 0.06 and $\chi^2/df <$ 3. The correlation between uniqueness levels was estimated when the content between two items was similar and the correlation was interpretable (Byrne, 2013; Jöreskog, 1993; Jöreskog & Sörbom, 1996).

2.4.3 | Regression weighting

The appropriateness of the manifest variables reflected its respective first factors and was judged based on the significance of unstandardized regression weights and standardized factor loading. The cut-off value for acceptable factor loading employed was 0.30 (Sellin & Keeves, 1997). Critical ratios were calculated by dividing the unstandardized regression coefficient by its respective standard error (SE). For factor loading regression analysis, the significance criterion was a critical ratio >1.96 (two-sided $p <$.05 level) (Bagozzi et al., 1991; Hox & Bechger, 1998).

2.5 | Data analysis

Descriptive statistics of the study population were obtained in SPSS 20.0 (IBM). Mean (*M*) values are reported with standard deviations (*SDs*). CFA, including modification index determination, SEM, and goodness of fit index calculations, was completed in Amos 21.0 (IBM).

3 | RESULTS

3.1 | Demographics

In this study, a total of 680 questionnaires were handed out and 629 responded (51 were nonresponsive), including 628 valid questionnaires and one invalid questionnaire. The response rate was 92.5%. The data set was randomly divided into a calibration ($N = 309$) and validation sample ($N = 319$), via random sampling using SPSS 20.0.

In the calibration sample, mean age was 57.7 years ($SD = 12.52$). Of the respondents, 164 (53.1%) were females; 230 (74.4%) were married; 272 (88.0%) had primary or higher level of education; 78.3% ($N = 242$) were unemployed; and 81.9% ($N = 253$) were religious. Patients were on haemodialysis for an average of 77.8 months ($SD = 61$ months).

In the validation sample, mean age was 58.5 years ($SD = 12.46$). Of the respondents, 159 (49.8%) were female; 245 (76.8%) were married; 278 (89.9%) had primary or higher level of education; 81.2% were unemployed ($N = 259$); and 84.6% were religious ($N = 270$). Patients were on haemodialysis for an average of 78.8 months ($SD = 63$ months). The sociodemographic and clinical characteristics of the calibration and validation samples are summarized in Table 1.

3.2 | CFA and SEM

Prior to modelling modification, the goodness of fit measures for the CFA-generated four-factor model indicated that the model did not fit the data very well. The fit test results and fit index values obtained for the model before and after modification are reported in Table 2. To improve the factor structure model, we identified following item

TABLE 1 Population sample characteristics

Variable	Calibration sample M; SD or N (%) (N = 309)	Validation sample M; SD or N (%) (N = 319)	p-Value
Age, years	57.70; 12.52	58.5; 12.46	.4226
Gender			
Male	145 (46.9)	160 (50.2)	.4257
Female	164 (53.1)	159 (49.8)	
Marital status			
Married	230 (74.4)	245 (76.8)	.5158
Single, widowed, separated, or divorced	79 (25.6)	74 (23.2)	
Education			
Illiterate	37 (12.0)	41 (12.9)	.809
Primary or higher degrees	272 (88.0)	278 (87.1)	
Employed			
No	242 (78.3)	259 (81.2)	.4273
Yes	67 (21.7)	60 (18.8)	
Religious			
No	56 (18.1)	49 (15.4)	.3926
Yes	253 (81.9)	270 (84.6)	
Dialysis history, months	77.88; 61.06	78.85; 63.57	.8455

TABLE 2 Fit indices across model development phases

Model (sample)	χ^2	df	χ^2/df	RMSEA	SRMR	CFI	TLI
Unmodified (calibration)	451.03	164	2.75	0.075	0.063	0.887	0.869
Modified (calibration)	224.14	128	1.75	0.049	0.045	0.954	0.945
Modified (validation)	223.29	128	1.74	0.048	0.048	0.958	0.950

Abbreviations: CFI, comparative fit index; NFI, normed fit index; RMSEA, root mean square error of approximation; SRMR, standardized root mean residual; TLI, Tucker-Lewis index.

TABLE 3 Modification indices of covariance and predicted parameter change

Associated entities	Modification index ^a	Parameter change ^b
Item 10, Item 16	51.23	0.285
Item 1, Item 2	73.57	0.250
Item 18, Item 20	6.93	0.112
Item 13, problem-solving dimension	11.24	0.092

^aIf analysis is repeated treating the item error covariances as a free parameter, the discrepancy falls by at least this amount.; ^bIf analysis is repeated treating the item error covariances as a free parameter, its estimate will become larger by approximately this value, compared to the present analysis.

content redundancies: both Item 10 (Controlling fluid intake to limit daily weight gain) and Item 16 (When I am thirsty for water, I will try to find ways) were related to Self-care; both Item 1 (When results of blood laboratory tests are not ideal) and Item 2 (Trying to figure out the underlying reasons for out-of-range blood tests) were related to Problem-solving; and both Item 18 (Reduce emotional stress from

dialysis) and Item 20 (I will seek help from others) were related to Emotional management. Additionally, we determined that Item 13 (I will search for information on kidney diseases) was related to the Problem-solving.

Covariance measurement error levels were highly correlated within the Item 10/Item 16, Item 1/Item 2, and Item 18/Item 20 pairs, and the measurement errors for latent variables were correlated between Item 13 and problem-solving (Table 3). Given the similarities of conceptual meaning summarized above, these correlated error terms indicated that these variables may share specific variance. The more extensive items of the similar item pairs were retained. Thus, we kept Item 1 and Item 16, and omitted Item 2 and Item 10. The modification indices indicated that the model fit could be improved by allowing the Item 18 and Item 20 errors to correlate. Despite the danger of chance capitalization (MacCallum et al., 1992), we decided to include these error terms in a re-specified model because both can be interpreted straightforwardly.

Although our CFA classified Item 13 originally as belonging to the emotional management factor, our modification indices showed that Item 13 associated strongly with the problem-solving factor. Indeed, seeking information can be considered a problem-solving behaviour

that indicates the patient is taking the initiative to solve a health/treatment problem. Thus, we inferred that the variance of Item 13 can be explained in the context of the problem-solving factor and loaded it on the problem-solving factor in our model.

As shown in Figure 1, the aforementioned changes improved the goodness of fit of the model. Goodness of fit index values obtained for the modified model indicating that the model fitted the data very well (see Table 2). Convergent validity of each scale was obtained at the .05 level.

3.3 | Factor loading

For our modified CFA-generated model, factors loading of items ranged from 0.46–0.83 with the calibration sample (Figure 1). The standard regression weight statistical data, including unstandardized regression weights with SEs, standardized regression weights and critical ratios obtained from our analysis of

the associations of each item (manifest variable) with its corresponding each subscale (latent variable) are reported in Table 4. All four HDSMI dimensions (i.e. partnership, self-care, problem-solving and emotion management) were confirmed as latent variables with statistically significant associations with several linked manifest variables.

3.4 | Cross-validation

For our modified CFA-generated model, factors loading of items ranged from 0.45–0.84 with the validation sample. The fit test results and fit index values obtained for the modified model with the validation sample are reported in Table 2. Notably, re-evaluation of the modified model showed that all of the fit indices were >0.9 with the validation sample, supporting the assumption of measurement stability, and thus indicating that our modified HDSMI-18 had model stability.

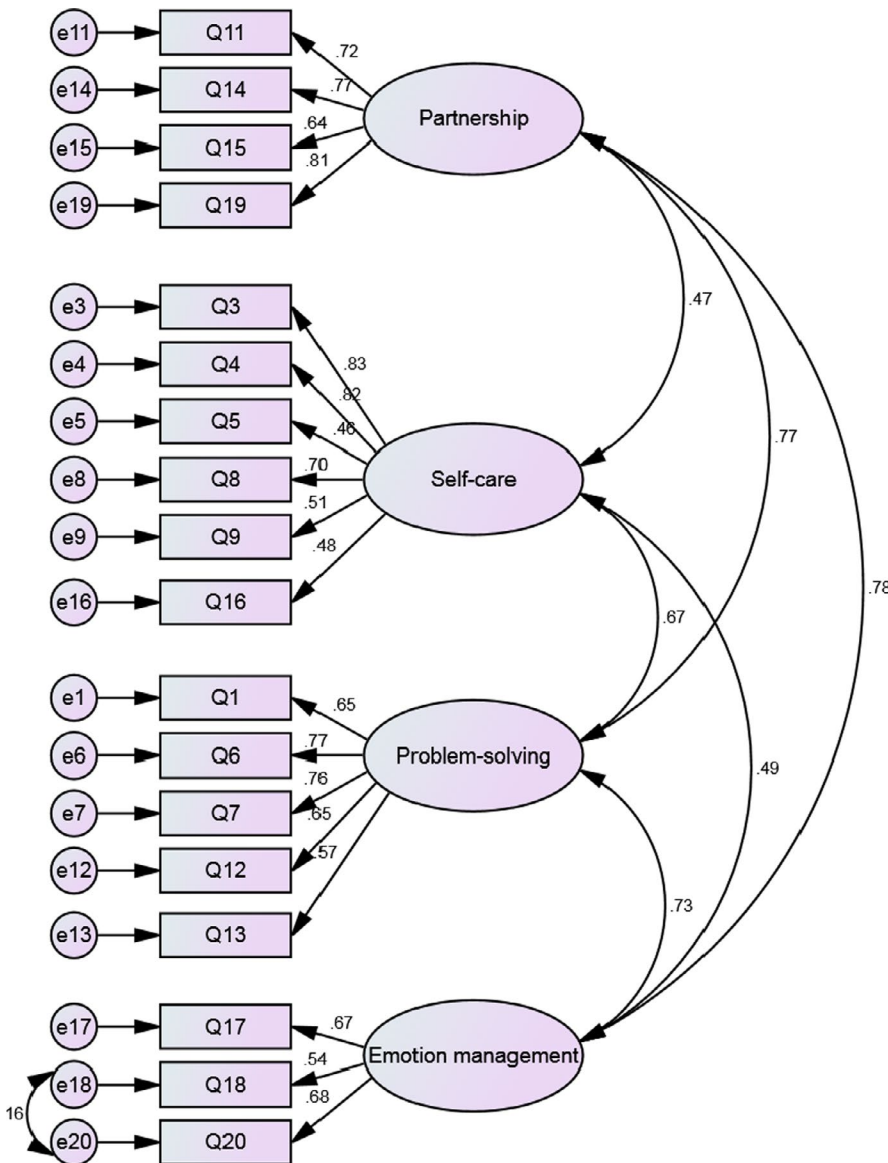


FIGURE 1 SEM results for the presently modified HDSMI-18 with the calibration sample

TABLE 4 Regression weight results for the modified model, HDSMI-18

Latent variables	Manifest variables ^a	Coefficients		
		B (SE) ^b	St beta ^c	Critical ratio
Partnership	19. I will discuss my expectations with HP	1.00	.81	
	15. I will make decisions with HP	0.83 (.07)	.64	11.19***
	14. I will proactively let HP know my expectations for desired goals	1.03 (.07)	.77	13.78***
	11. I will check the settings on the dialysis machine	0.94 (.07)	.72	12.75***
Self-care	8. I will follow the guidance of HP	1.00	.70	
	5. I will surely take care of my arteriovenous fistulae	0.57 (.08)	.46	7.40***
	4. I will specifically choose foods low in potassium	1.08 (.09)	.82	12.61***
	3. I will specifically meet dietary requirements	1.14 (.09)	.83	12.79***
	9. Before haemodialysis, I will...	0.80 (.10)	.51	8.21***
	16. When I am thirsty for water, I will try to find ways	0.59 (.08)	.48	7.73***
Problem-solving	7. When I have feelings of discomfort	1.00	.76	
	6. When I have problems concerning kidney diseases, I will take the initiative to inquire others.	1.02 (.08)	.77	13.28***
	1. When results of blood lab tests are not ideal	0.92 (.08)	.65	11.09***
	12. When I ingest foods high in phosphorus	0.99 (.09)	.65	11.12***
	13. I will search for information on kidney diseases	0.82 (.08)	.57	9.64***
	Emotional management	20. I will seek help from others	1.00	.68
18. Reduce emotional stress from dialysis		0.83 (.10)	.54	8.31***
17. I can talk to HP comfortably		1.00 (.11)	.67	8.75***

Abbreviation: HP, healthcare providers.

^aNumbers shown are item numbers on the questionnaire.; ^bB (SE), unstandardized regression weight (standard error); ^cSt beta, standardized regression weight.; *** $p < .001$.

4 | DISCUSSION

An initial CFA was conducted with the Song and Lin's (2009) 20-item HDSMI. The CFA toolbox allowed items that have weak relationships with their corresponding factors (factor loading < 0.3) (Nunnally, 1994) to be altered. We were able to improve the full variety of fit indices calculated, by deleting Items 2 and 10 (retaining the similar Items 1 and 16, respectively), allowing covariance of Items 18 and 20, and reexamining the factor loading of Item 13. After reviewing the meaning of Item 13, we determined that it was appropriate to reassign it to the "problem-solving." Hence, with

these modifications, the item composition of the original 20-item HDSMI was altered from seven items in the "self-care" dimension to six items, and from four items in the "emotional management" dimension to three items. The "partnership" dimension was unaltered. Notably, the "problem-solving" dimension deleted a redundant item, but received the reassigned Item 13, keeping it a five-item dimension. The construct validity of the resultant modified, HDSMI-18, which retained the four-factor structure, was supported by the present CFA results.

CFA of the HDSMI confirmed its four-factor structure. The latent variables corresponded to the instrument's four subscales:

partnership, self-care, problem-solving and emotional management. Goodness of fit was improved by removing redundancies between two item pairs, allowing correlation of the variance of a third pair of items, and transferring the loading of one item to a difference factor/dimension. This study confirmed that the modified HDSMI-18 has good construct validity in both the calibration sample and the validation sample.

Self-management has been shown to play an important role in health maintenance and quality of life. Although self-management for patients on haemodialysis has been explained (Curtin et al., 2005), there is limited empirical research regarding the use of instruments in monitoring of self-management behaviours and obstacles. Self-management instruments of ESRD patients have generally emphasized on the implementation of self-care activities, with limited focus on haemodialysis maintenance (Chiang et al., 2001; Curtin et al., 2004; Riegel et al., 2000). The HDSMI in this study addresses both self-care activities and haemodialysis maintenance. There are many self-management instruments developed for different chronic diseases, but the purpose of this study is to verify self-management instruments for haemodialysis patients. In the following, we will discuss the HDSMI-18 and the instrument developed by Curtin et al. (2004).

In the self-management instrument constructed by Curtin et al. (2004), item in the "self-care during haemodialysis" dimension included questions like "Helped decide where the needles should be placed?" and "Helped decide the blood flow rate?" These items fall under the "partnership" dimension in our study. The previous study (Song & Lin, 2009) indicated that patients could still propose their own treatment options to healthcare providers while performing "self-care during haemodialysis." In contrast to Curtin et al.'s instrument, the self-care activities of haemodialysis patients in the HDSMI-18 cover daily life management. This differs from Curtin et al.'s instrument which only assessed the self-care activities of patients during haemodialysis. Examples of items from Curtin et al.'s instrument include: "Specially select low potassium vegetables and fruits" and "Control the intake of water so that the daily weight gain does not exceed one kilogram." Additionally, items of the "emotional management" dimension in the HDSMI-18 showed that haemodialysis patients are inclined to choose more proactive and positive approaches to resolving doubts regarding their illnesses. Patients are found to rely on family members or religious beliefs to deal with the long-term emotional distresses caused by their diseases. Frequent contacts with medical staffs are also important for patients to deal with the psychological pressures of undergoing haemodialysis.

4.1 | Strengths and limitations

Compared to Curtin et al.'s (2004) instrument, which had 37 items, the HDSMI had only 18 items. It took approximately 5–10 min to complete the questionnaires. Patients felt relatable to the questions, as they are composed of problems that patients typically encountered in their daily lives. The above showed that the instrument was

easy to understand and acceptable for the participants, which made it suitable for measuring the long-term self-management of patients on haemodialysis.

In addition, the instrument recruited patients from different levels of health facilities, such as medical centres, regional teaching hospitals and private dialysis centres. Therefore, it was safe to predict that the future application of the HDSMI-18 would not be limited by the types of health facilities. Different types of health facilities would not affect the measurement results of the instrument. The instrument's applicability to different types of health facilities showed good external validity.

This study has potential limitations due to regional constraint. Accessible population is limited to the southern Taiwan. To evaluate the ecological validity and applicability of the HDSMI-18, samples from different populations beyond southern Taiwan and longitudinal studies that examines the predictive validity of the HDSMI-18 are recommended for future studies.

5 | CONCLUSION AND IMPLICATIONS

CFA findings in this study confirmed the four-factor structure of the 20-item HDSMI (i.e. Partnership, Self-care, Problem-solving and Emotion management) through EFA, which showed four modifications improved the instrument's construct validity. All goodness of fit indices showed that the modified HDSMI-18 is valid and reliable for use on patients undergoing haemodialysis. In nursing practice, this HDSMI with 18 items verified by CFA could be a valuable assessment tool for clinicians to identify problems with self-management of patients undergoing haemodialysis through which healthcare providers could further provide individualized care. This instrument can provide nurses with a guideline that promptly assesses self-management problems of patients receiving haemodialysis. This tool could benefit nursing managers to improve the quality of care through periodically assessing and identifying patient's difficulty areas in self-management using the HDSMI-18. Compared with the 20-item HDSMI constructed by EFA, this HDSMI-18 verified by CFA is more powerful for researches and clinician to use in their areas.

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CONFLICT OF INTEREST

To the best of our knowledge, the named authors have no conflict of interest, financial or otherwise.

AUTHOR CONTRIBUTIONS

Wen-Chun Chen: Substantial contributions to the conception or design of the work; interpretation of data for the work; Drafting the work or revising it critically for important intellectual content. Chiu-Chu Lin: Final approval of the version to be published; interpretation

of data for the work; Drafting the work or revising it critically for important intellectual content. Chia-Chen Wu: Interpretation of data for the work; Drafting the work or revising it critically for important intellectual content. Yi-Chun Song: Interpretation of data for the work.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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