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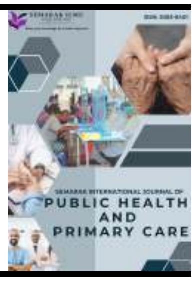

Psychometric Properties of Self-Management Instruments for Catheter-Related Bloodstream Infection (CRBSI) Prevention among Haemodialysis Patients: A Systematic Review of Validation Studies

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ABSTRACT

Catheter-related bloodstream infection (CRBSI) remains a major cause of morbidity and mortality among haemodialysis patients, particularly those dependent on central venous catheters. Effective patient self-management is essential for infection prevention; however, the availability of validated instruments assessing CRBSI-specific self-management behaviours remains unclear. This systematic review aimed to evaluate the psychometric properties of self-management questionnaires used among adult haemodialysis patients and to determine their relevance to CRBSI prevention. A systematic review of validation studies was conducted using semantic searches of literature indexed in Semantic Scholar and OpenAlex. Studies examining the psychometric properties of self-management instruments among adult haemodialysis patients were included. Data extraction focused on instrument characteristics, assessed domains, reliability, validity, and relevance to infection prevention. Thirteen validation studies from Asia, Europe, Africa, and South America met the inclusion criteria. Most instruments demonstrated acceptable to excellent psychometric properties. Cronbach's alpha values ranged from 0.57 to 0.972, and test–retest reliability coefficients generally exceeded 0.80. Factor analysis explained between 50.85% and 69.41% of the total variance. Despite strong measurement properties, only one instrument addressed infection prevention behaviour, limited to hand hygiene. No validated questionnaire specifically assessed CRBSI-related self-management behaviours such as catheter exit-site care or early recognition of infection signs. Development and validation of a patient-centred CRBSI prevention questionnaire is urgently needed.

1. Introduction

1.1 Background of the Study: Catheter-Related Bloodstream Infection in Haemodialysis

Catheter-related bloodstream infection (CRBSI) remains one of the most serious and largely preventable complications affecting patients with end-stage renal disease undergoing maintenance haemodialysis. Catheter-related infections in haemodialysis are strongly associated with sepsis, prolonged hospitalisation, and increased mortality, placing a substantial burden on patients and healthcare systems [14]. Despite clinical recommendations favouring arteriovenous fistulas because

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of their lower infection risk, central venous catheters continue to be widely used in routine practice, particularly among elderly patients, individuals with multiple comorbidities, and those initiating dialysis urgently without prior vascular access planning [12].

Among catheter-related complications, CRBSI is recognised as the most clinically significant due to its direct impact on morbidity and survival. Ibrahim *et al*., [14] demonstrated that haemodialysis catheter infections are associated with adverse clinical outcomes and showed that structured health education programmes can significantly reduce infection incidence [14]. In addition to direct clinical consequences, CRBSI contributes to increased healthcare utilisation through repeated hospital admissions, catheter replacement procedures, and prolonged antimicrobial therapy [13]. These findings reinforce the importance of prioritising CRBSI prevention within haemodialysis care.

Over the past two decades, infection prevention strategies have focused primarily on healthcare provider–driven measures, including standardised catheter insertion techniques, aseptic handling practices, antimicrobial lock therapy, and exit-site surveillance [15]. Although these approaches have reduced infection rates in some settings, catheter-related infections persist, particularly among high-risk haemodialysis populations [14]. The continued occurrence of CRBSI highlights the need to address patient-related behaviours that influence infection risk beyond the dialysis unit.

1.2 The Role of Patient Self-Management in Haemodialysis Care

Self-management is a core component of chronic disease care and refers to an individual's ability to manage treatment demands, health-related behaviours, and the psychosocial consequences of living with a long-term condition. In haemodialysis populations, self-management encompasses behaviours such as adherence to dialysis schedules, dietary and fluid restrictions, medication use, symptom monitoring, and vascular access care [2]. Effective self-management has been associated with improved clinical outcomes and enhanced quality of life among patients receiving long-term dialysis therapy [1].

Although healthcare professionals are responsible for catheter insertion and infection control practices within dialysis units, patients play a critical role in maintaining catheter integrity outside the clinical setting. Daily behaviours such as appropriate hand hygiene, protection of catheter dressings, avoidance of unnecessary catheter manipulation, and early recognition of infection-related signs represent a key defence against CRBSI [13]. Inadequate self-management can compromise even the most rigorous clinical protocols, thereby increasing infection risk.

The clinical importance of patient self-management in infection prevention is further supported by intervention studies demonstrating that structured education and behavioural programmes can reduce catheter-related infection rates. Educational interventions targeting catheter care practices and symptom recognition have been shown to improve patient knowledge and reduce CRBSI incidence [14]. These findings underscore the importance of actively engaging patients as partners in infection prevention strategies.

1.3 Measurement of Self-Management in Haemodialysis: Existing Instruments

Accurate measurement of self-management behaviours is essential for identifying patients at risk of poor adherence, guiding educational interventions, and evaluating the effectiveness of self-management programmes in haemodialysis care. Several patient-reported instruments have been developed to assess self-management and self-care behaviours among haemodialysis patients.

Among these instruments, the Hemodialysis Self-Management Instrument (HDSMI) was originally developed in Taiwan and subsequently underwent psychometric refinement, including validation of a shortened 18-item version by Chen *et al.,* [3], followed by cross-cultural adaptations in Turkey [4,11]. The instrument assesses general self-management capacity across multiple domains, including problem-solving, emotion regulation, and interactions with healthcare professionals [3]. Cross-cultural adaptations conducted in Turkish populations further demonstrated acceptable reliability and construct validity, supporting the instrument's stability across sociocultural contexts [4,11]. Validation studies conducted in Greek haemodialysis populations also demonstrated acceptable psychometric performance for other disease-related self-management instruments [1].

Despite their psychometric strengths, these instruments were designed to assess overall self-management rather than infection-specific behaviours. As a result, catheter-related practices essential for CRBSI prevention, such as exit-site care, dressing protection, and early symptom recognition, are not comprehensively captured.

1.4 Vascular Access Self-Care Instruments and their Limitations

In addition to general self-management tools, several instruments have been developed to assess self-care behaviours related to vascular access, particularly among patients with arteriovenous fistulas. A psychometric evaluation conducted in Korea demonstrated strong reliability and validity for a self-management scale focused on fistula-related care behaviours [5]. Validation studies conducted in Turkey confirmed the applicability of fistula-focused self-care instruments in different cultural contexts [6]. Similar psychometric properties were reported in Brazilian haemodialysis populations following scale adaptation [8]. Cross-cultural validation in Moroccan patients further supported the reliability of arteriovenous fistula self-care assessment tools [9].

More recently, a short-form vascular access questionnaire was developed to improve assessment efficiency while maintaining acceptable psychometric properties [12]. However, these instruments focus primarily on fistula-related practices. Because catheter care involves distinct infection risks and aseptic requirements, findings derived from fistula-focused self-care instruments cannot be directly generalised to catheter-dependent haemodialysis patients.

1.5 Infection-Specific Measurement Approaches

Relatively few instruments focus explicitly on infection prevention behaviours in haemodialysis care, despite the clinical importance of this domain. An infection prevention instrument validated by Cruz et al. addressed measures related to central catheter–associated bloodstream infection prevention but did not comprehensively assess patient self-management behaviours across the full range of daily catheter care activities [13].

An innovative approach to infection surveillance is represented by the REDS scale, which enables structured assessment of exit-site conditions and facilitates early detection of infection-related changes. Implementation of this clinician-administered tool has been associated with significant reductions in long-term catheter-related infection rates [15]. However, because the REDS scale is administered by healthcare professionals, it does not evaluate patient self-management behaviours and is therefore limited as a patient-reported outcome measure.

1.6 Psychometric Approaches in Self-Management Research

Most validation studies and self-care instruments have been validated using Classical Test Theory–based approaches. These studies commonly report internal consistency reliability using Cronbach's alpha and examine construct validity through factor analysis. While these methods provide useful information regarding overall scale performance, they assume equal item contribution and treat ordinal response categories as linear measurements, which limits measurement precision.

In contrast, modern psychometric approaches based on the Rasch Measurement Model address these limitations by modelling the relationship between person ability and item difficulty within a probabilistic framework. Rasch analysis enables transformation of ordinal data into interval-level measures and supports rigorous evaluation of unidimensionality and item functioning. Despite these advantages, to date, no published haemodialysis self-management instrument identified in this review has applied Rasch-based validation, indicating a methodological gap in the current literature.

1.7 Research Gap and Significance

CRBSI remains a persistent and clinically significant complication among haemodialysis patients who rely on central venous catheters, despite the implementation of educational initiatives and infection control measures [14]. However, existing self-management instruments are largely designed to assess general disease management behaviours and do not adequately capture catheter-specific infection prevention practices [2]. Instruments focusing on vascular access self-care primarily address arteriovenous fistula management and therefore have limited applicability to catheter-dependent haemodialysis populations [5]. Although infection-focused tools such as the REDS scale have demonstrated clinical effectiveness, they do not directly assess patient self-management behaviours related to CRBSI prevention [15].

Furthermore, most haemodialysis self-management instruments have been validated using Classical Test Theory–based approaches, which provide limited insight into item-level performance, behavioural difficulty, and measurement precision [4]. The lack of a patient-reported, CRBSI-specific self-management instrument validated using modern psychometric methods represents a critical gap in haemodialysis research. Therefore, the objective of this study is to synthesise existing evidence on self-management measurement in haemodialysis care and to establish a robust psychometric foundation to inform the development of a patient-centred, Rasch-validated instrument for assessing CRBSI prevention behaviours among catheter-dependent haemodialysis patients. Addressing this gap has the potential to support more targeted educational interventions and contribute to improved infection prevention outcomes in haemodialysis care. To illustrate the conceptual relationships among patient knowledge, self-management behaviours, psychosocial factors, and catheter-related bloodstream infection prevention, a conceptual framework guiding the present review is presented in Figure 1:

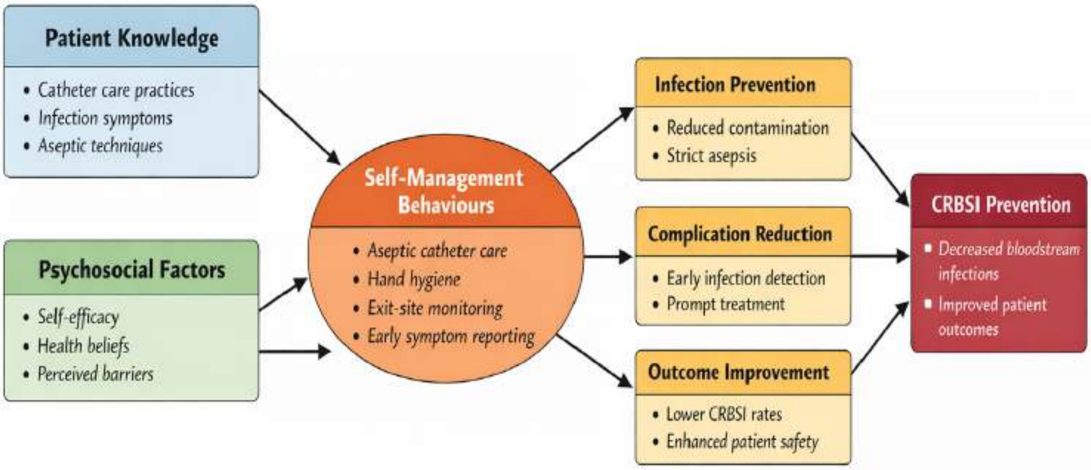

Fig. 1. Conceptual framework of patient self-management for CRBSI prevention among haemodialysis patients

2. Methodology

2.1 Study Design

This study was conducted as a systematic review of validation studies examining instruments used to assess self-management, self-care behaviours, adherence, or infection-prevention practices among adult haemodialysis patients. The review focused on instruments relevant to haemodialysis self-management and examined their applicability to CRBSI prevention.

A systematic review design was selected to ensure methodological transparency, reproducibility, and comprehensive synthesis of existing evidence. This approach is particularly appropriate for identifying conceptual and methodological gaps in instrument development and validation, which cannot be adequately addressed through single empirical studies. The review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to guide the identification, screening, eligibility assessment, and inclusion of studies.

2.2 Search Strategy and Information Sources

A comprehensive literature search was conducted to identify relevant validation studies published in peer-reviewed journals. To ensure thorough coverage of interdisciplinary literature across nursing, nephrology, and psychometrics, a semantic search strategy was employed rather than reliance solely on keyword-based database queries.

The primary search was conducted using the Elicit semantic search engine, which indexes a large corpus of academic publications derived from Semantic Scholar and OpenAlex. Semantic search was selected because it enables the identification of conceptually relevant studies even when terminology varies across disciplines or cultural contexts. This approach is important in psychometric research, where similar constructs may be described using different terms such as “self-management,” “self-care,” “adherence,” or “behavioural competence.”

Search queries combined core concepts related to:

i. Haemodialysis or Hemodialysis
ii. Vascular access or catheter use
iii. Self-management, self-care, or adherence
iv. Instrument development or validation

The search strategy was intentionally broad to reduce the likelihood of omitting relevant instruments. Manual screening of reference lists from included studies was also undertaken to identify additional eligible articles not retrieved through the primary search. The literature search was conducted in January 2026 and included studies published up to January 2026.

2.3 Eligibility Criteria

Studies were screened and selected based on predefined inclusion and exclusion criteria developed in accordance with PRISMA recommendations.

2.3.1 Inclusion criteria

Studies were included if they met all of the following criteria:

i. Population: Adult patients (≥18 years) undergoing maintenance haemodialysis.
ii. Vascular Access: Studies involving patients using central venous catheters or instruments applicable to catheter-dependent haemodialysis populations. Instruments primarily developed for arteriovenous fistula care were included only if they were validated within haemodialysis populations and reported psychometric properties relevant to self-care assessment.
iii. Instrument Type: Studies reporting the development, adaptation, or validation of patient-reported outcome measures (PROMs) assessing self-management, self-care behaviours, adherence, or infection-prevention practices.
iv. Psychometric Evaluation: Studies reporting at least one psychometric property, such as internal consistency reliability, construct validity, content validity, or factor structure.
v. Publication Type: Peer-reviewed original research articles published in English.

2.3.2 Exclusion criteria

Studies were excluded if they met any of the following criteria:

i. Involved paediatric populations only.
ii. Focused exclusively on peritoneal dialysis.
iii. Evaluated clinical outcomes without reporting instrument validation.
iv. Were qualitative studies, editorials, conference abstracts, or review articles.
v. Lacked sufficient methodological detail to assess psychometric quality.

2.4 Study Selection Process

All identified records were imported into a reference management system, and duplicate records were removed before screening. Study selection was conducted in three sequential stages in accordance with PRISMA guidelines:

i. Title Screening: Titles were screened to remove clearly irrelevant records.
ii. Abstract Screening: Abstracts were reviewed to assess relevance based on population, instrument focus, and study design.

iii. Full-Text Review: Full-text articles were assessed against the inclusion and exclusion criteria to determine final eligibility.

The study selection process and reasons for exclusion at each stage are illustrated in Figure 2:

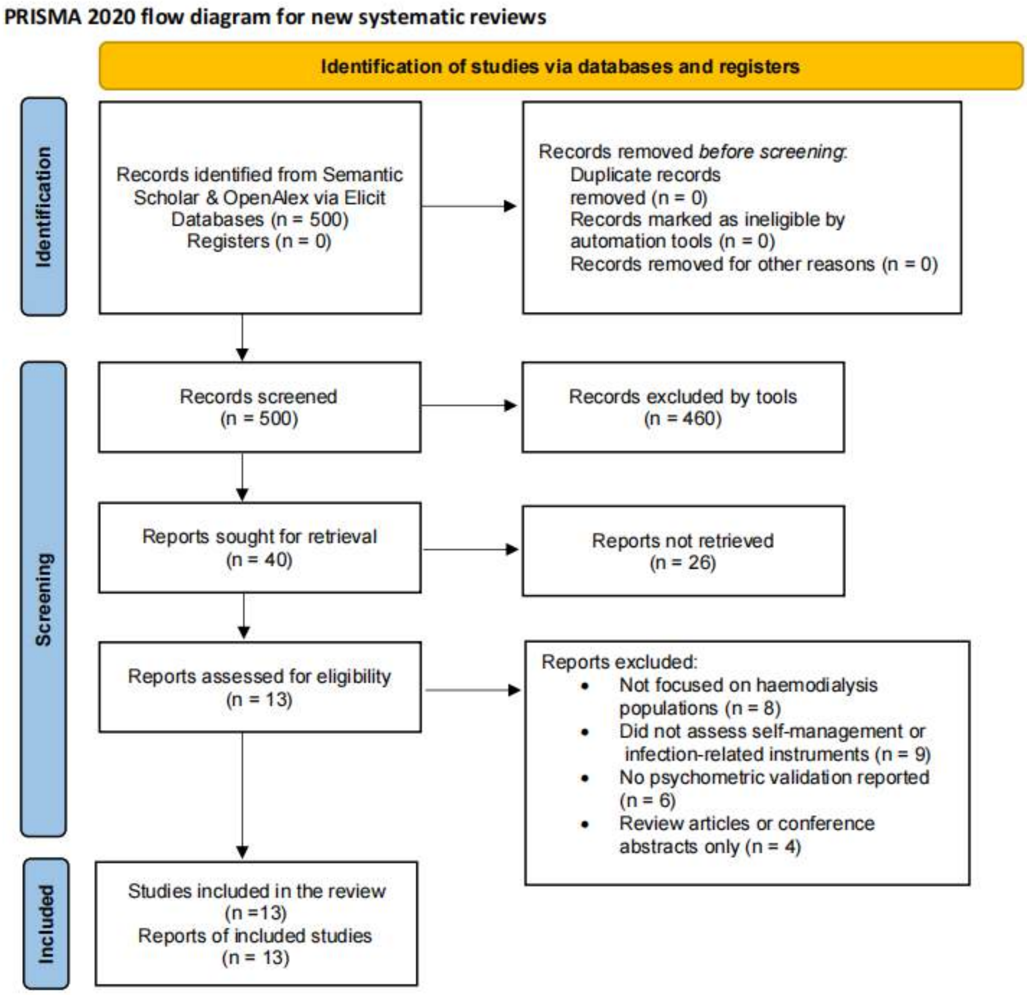

Fig. 2. PRISMA flow diagram illustrating study selection process

2.5 Data Extraction

Data extraction was conducted using a structured extraction form developed specifically for this review. The following information was extracted from each included study:

i. Author(s) and year of publication
ii. Country and cultural context
iii. Study design and sample size
iv. Characteristics of the study population
v. Instrument name and theoretical basis
vi. Number of items and response format
vii. Psychometric properties reported (e.g., reliability, validity)
viii. Statistical methods used for validation

Data extraction focused not only on reported psychometric outcomes but also on methodological approaches used in instrument validation, particularly the reliance on CTT methods.

2.6 Psychometric Evaluation Framework
2.6.1 Classical Test Theory (CTT)

CTT-based analyses typically included internal consistency reliability testing using Cronbach's alpha, exploratory factor analysis, confirmatory factor analysis, and content validity assessment, as reported in validation studies of haemodialysis self-management and vascular access self-care instruments [5]. Similar CTT-based approaches were applied in subsequent validation studies conducted across different cultural contexts [6]. Further psychometric evaluations in Brazilian and Moroccan populations also relied on CTT methods to establish reliability and construct validity [8]. Recent adaptations and validation studies have continued to employ CTT as the primary psychometric framework [9].

2.6.2 Rasch measurement model as an evaluative lens

None of the included studies applied Item Response Theory or Rasch analysis. This review used the principles of the Rasch Measurement Model as a conceptual evaluative framework to examine limitations of existing validation approaches conceptually.

The Rasch model conceptualizes the probability of a given response as a function of a person's ability and item difficulty, allowing transformation of ordinal data into interval-level measures. Key Rasch principles considered in this review included:

i. Unidimensionality: Whether instruments appear to measure a single latent construct related to self-management or infection prevention.
ii. Item Difficulty Coverage: Whether items conceptually span a range of behaviours from basic to advanced self-management.
iii. Potential Item Misfit: Whether certain behaviours may be inconsistently endorsed relative to expected difficulty levels.

By applying these principles conceptually, the review identifies methodological gaps and provides a rationale for future Rasch-based instrument development. The conceptual distinctions between CTT and the Rasch Measurement Model, which underpin the need for modern psychometric evaluation, are illustrated in Figure 3:

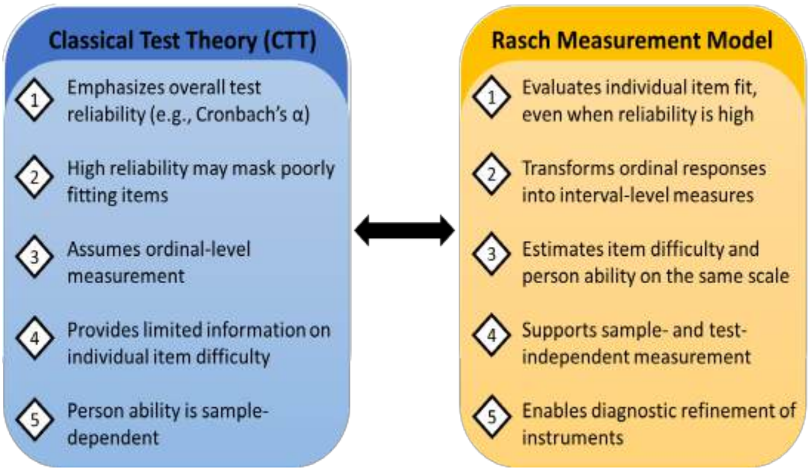

Fig. 3. Comparison of CTT and Rasch Measurement Model in self-management assessment

2.7 Data Synthesis

Due to heterogeneity in instrument content, validation methods, and reported outcomes, a meta-analysis was not conducted. Instead, a narrative synthesis approach was used to summarize and compare findings across studies.

The synthesis focused on:

i. Types of instruments used.
ii. Domains assessed.
iii. Psychometric properties reported.
iv. Relevance to CRBSI prevention.
v. Methodological limitations.

Tables were used to enhance clarity and facilitate comparison across studies.

2.8 Methodological Rigor and Transparency

This review adhered to established standards for systematic reviews, including transparent reporting, predefined eligibility criteria, and structured data extraction. Methodological rigor was further strengthened by the explicit evaluation of psychometric approaches rather than reliance solely on reported reliability coefficients.

By systematically examining both what was measured and how it was measured, this methodology provides a robust foundation for identifying gaps in current self-management assessment practices and informing future instrument development.

2.9 Ethical Considerations

As this study was based exclusively on published literature and did not involve human participants or identifiable data, formal ethical approval was not required. All included studies were conducted in accordance with ethical standards applicable in their respective contexts.

2.10 Summary

In summary, this systematic review employed a rigorous and transparent methodology to identify, evaluate, and synthesise validation studies of self-management instruments used among haemodialysis patients. By integrating PRISMA-guided review processes with a modern psychometric evaluative lens, the methodology supports the study's objective of advancing patient-centred, methodologically robust assessment of CRBSI prevention behaviours.

3. Results

3.1 Study Selection and Overview of Included Studies

The systematic search and study selection process identified thirteen studies that met the predefined inclusion criteria. The PRISMA flow diagram illustrating identification, screening, eligibility assessment, and final inclusion is presented in Figure 2.

The included studies were published between 2013 and 2025. They represented diverse geographical regions across Asia, Europe, Africa, and South America, including China, Korea, Taiwan, Turkey, Vietnam, Greece, Portugal, Brazil, Morocco, and Poland. Sample sizes ranged from 120 to 300 participants, with most studies enrolling between 150 and 300 haemodialysis patients, which is generally considered adequate for psychometric evaluation using Classical Test Theory (CTT) approaches.

Most studies employed cross-sectional validation designs conducted in hospital-based or outpatient haemodialysis centres. Several instruments were originally developed for patients with arteriovenous fistulas (AVF), while others applied to mixed vascular access populations or specifically to central venous catheter (CVC) users.

A comprehensive summary of study characteristics, psychometric properties, and relevance to catheter-related bloodstream infection (CRBSI) prevention is presented in Table 1.

Table 1
Characteristics, psychometric properties, and CRBSI relevance of included studies (n = 13)

Author (Year)	Country	Instrument	Sample Size	Access Type	Main Construct	Cronbach's α	Validity Method	Variance Explained	CRBSI-Specific Content	Measurement Model
Zhang & Hu (2013)	China	Hand Hygiene Questionnaire	300	CVC	Infection prevention behaviour	0.972	Content validity + EFA	Not reported	Yes (Hand hygiene)	CTT
Cha & Kang (2017)	Korea	HDSMI-K	215	Mixed	Self-management	0.83–0.89	CFA	60–65%	No	CTT
Chen et al. (2021)	Taiwan	HDSMI-18	200	Mixed	Self-management	0.87–0.93	EFA	63.3%	No	CTT
Lee et al. (2017)	Korea	Self-management scale for HD patients with AVF	178	AVF	AVF self-care	0.85–0.92	EFA	52–68%	No	CTT
İkiz et al. (2020)	Turkey	ASBHD-AVF	160	AVF	AVF self-care	0.88–0.94	CFA	60–67%	No	CTT
Lira et al. (2021)	Brazil	ASBHD-AVF	300	AVF	AVF self-care	0.90–0.95	CFA	61–69%	No	CTT
Loubna et al. (2025)	Morocco	ASBHD-AVF	283	AVF	AVF self-care	0.89–0.94	CFA	60–66%	No	CTT

Nguyen et al. (2023)	Vietnam	SUPPH-V	127	Mixed	Self-efficacy	0.86–0.95	CFA	50.85%	No	CTT
Özdemir & Yeşilbalkan (2025)	Turkey	HDSMI-18 (Turkish version)	200	Mixed	Self-management	0.77	Content validity + EFA + CFA	Five-factor structure	No	CTT
Barros et al. (2023)	Portugal	SF-VAQ	156	Mixed	Vascular access satisfaction	0.80–0.89	EFA	53–60%	Indirect	CTT
Alikari et al. (2018)	Greece	Kidney Disease Questionnaire	150	Mixed	Disease-related quality of life	0.57–0.88	EFA	Not clearly reported	No	CTT
Cruz et al. (2023)	Brazil	CA-BSI prevention questionnaire	120	CVC	Catheter infection prevention	0.92	Content validity + EFA	Not reported	Yes (CA-BSI)	CTT
Porażko et al. (2021)	Poland	REDS Scale	145	CVC	Exit-site infection monitoring	Not applicable *	Clinical validation	Not reported	Yes (Monitoring tool)	Clinician-administered

*REDS is clinician-administered and does not report Cronbach's alpha as a patient-reported instrument

3.2 Characteristics of Identified Instruments

The included studies encompassed six broad categories of instruments:

i. General haemodialysis self-management instruments,
ii. Vascular access–focused self-care instruments,
iii. Infection-specific behaviour questionnaires,
iv. Clinician-administered infection monitoring tools,
v. Self-efficacy measures, and quality-of-life instruments related to disease management.

3.2.1 General self-management instruments

The Hemodialysis Self-Management Instrument (HDSMI), originally developed in Taiwan, has undergone multiple cross-cultural validations, including the Korean version (HDSMI-K), the shortened HDSMI-18, and the Turkish adaptation [2-4,11]. The Turkish validation identified a modified 17-item structure with five subdimensions, demonstrating acceptable internal consistency ($\alpha = 0.77$) under Classical Test Theory. These instruments assessed multidimensional behaviours including problem-solving, emotional regulation, self-care practices, and patient–provider interaction. Although psychometrically robust, they were designed to measure general disease management rather than catheter-specific infection prevention.

3.2.2 Vascular access–focused instruments

Several studies validated instruments assessing AVF self-care behaviours, including monitoring of bruit and thrill, protection of the access site, and complication awareness. While these instruments demonstrated strong reliability and construct validity, their applicability to catheter-dependent patients is limited because catheter care requires distinct infection-prevention behaviours.

3.2.3 Infection-specific and monitoring instruments

Only two patient-reported instruments directly addressed infection prevention behaviours. The hand hygiene questionnaire focused exclusively on hand hygiene practices, while the CA-BSI prevention questionnaire evaluated catheter-related infection control measures. Neither instrument comprehensively assessed the full spectrum of CRBSI-related self-management behaviours.

The REDS scale, evaluated in Poland, is a clinician-administered monitoring tool assessing exit-site redness, oedema, discharge, and tenderness. Although clinically valuable, it does not function as a patient-reported self-management instrument.

3.3 Psychometric Properties
3.3.1 Reliability

Under CTT, most patient-reported instruments demonstrated acceptable to excellent internal consistency reliability. Cronbach's alpha coefficients ranged from 0.57 to 0.972, as shown in Table 1. AVF-focused instruments frequently reported alpha values exceeding 0.90, suggesting strong internal coherence among items. However, test–retest reliability and responsiveness were infrequently reported.

3.3.2 Validity

Construct validity was primarily assessed using exploratory and confirmatory factor analysis. Across studies, factor solutions explained approximately 50% to 69% of total variance. Content validity was commonly established through expert panel review. However, criterion validity, predictive validity, and responsiveness were rarely evaluated.

Notably, none of the patient-reported instruments employed Rasch analysis or Item Response Theory methods to assess item-level performance or measurement invariance.

3.4 Methodological Approaches to Validation

All patient-reported instruments relied exclusively on Classical Test Theory–based methods for psychometric evaluation. These approaches provided estimates of internal consistency and dimensionality but did not generate item difficulty parameters or behavioural hierarchies. Measurement invariance across demographic or cultural subgroups was not formally examined. The absence of modern psychometric modelling represents a methodological limitation within the current evidence base.

3.5 Relevance to CRBSI Prevention

The degree to which existing instruments directly addressed CRBSI prevention varied substantially. General self-management and AVF-focused instruments did not comprehensively assess catheter-specific infection prevention practices. Infection-specific questionnaires addressed isolated behaviours such as hand hygiene or selected catheter care measures but did not capture multidimensional self-management behaviours required for effective CRBSI prevention.

No instrument comprehensively evaluated behaviours such as exit-site dressing care, moisture management, early recognition of infection signs, and patient decision-making regarding catheter complications within a single validated framework.

3.6 Clinical Evidence Supporting the Behavioural Importance

Although comprehensive CRBSI-focused self-management instruments were lacking, clinical evidence from included studies supports the importance of behavioural and monitoring strategies. Implementation of structured infection monitoring using the REDS scale was associated with a reduction in catheter-related infection incidence. These findings highlight the potential clinical impact of structured behavioural assessment, despite the absence of a comprehensive patient-reported CRBSI self-management instrument.

3.7 Summary of Results

In summary, existing instruments assessing self-management and self-care behaviours among haemodialysis patients demonstrate acceptable psychometric performance under Classical Test Theory. However, most focus on general disease management or AVF care. Infection-specific tools address isolated behaviours or rely on clinician-administered monitoring.

No validated instrument comprehensively measures catheter-related bloodstream infection prevention behaviours from a patient self-management perspective. Furthermore, modern psychometric approaches such as Rasch analysis have not been applied. These findings highlight both a conceptual and methodological gap in the current measurement landscape.

4. Discussion

4.1 Principal Findings

This systematic review synthesised evidence from thirteen validation studies evaluating self-management, self-care, and infection-related instruments among haemodialysis patients. The findings indicate that although several instruments demonstrate acceptable psychometric properties under Classical Test Theory (CTT), none were developed to assess patient self-management behaviours specific to CRBSI prevention comprehensively. Most instruments focused on general haemodialysis self-management or arteriovenous fistula care, with infection prevention addressed only indirectly.

As presented in Table 1, the Hemodialysis Self-Management Instrument (HDSMI), originally developed in Taiwan and later refined into the shortened HDSMI-18 [3], has undergone cross-cultural validation in Korean and Turkish populations [2,4,11]. The Turkish adaptation identified a modified five-factor structure and reported acceptable internal consistency ($\alpha = 0.77$), further supporting the instrument's adaptability across sociocultural contexts.

In contrast, vascular access–focused instruments such as the AVF self-care scale developed by Lee *et al.,* [5] and later validated in Turkey and Brazil [6,8] demonstrated strong psychometric performance but were specifically designed for fistula-dependent populations.

4.2 Interpretation in the Context of Existing Literature

The reliance on general self-management instruments reflects a broader conceptual pattern in renal nursing research. Chen *et al.,* [3] conceptualised haemodialysis self-management across domains such as problem-solving, emotional regulation, and interaction with healthcare providers, while Cha and Kang [2] confirmed the multidimensional structure in the Korean validation.

The hand hygiene questionnaire validated by Zhang and Hu [17] addressed an essential infection-prevention behaviour and demonstrated satisfactory reliability. Nevertheless, it evaluated only a single preventive action and did not encompass broader catheter-care practices. In contrast, the REDS scale introduced by Porażko *et al.,* [15] provided structured clinical monitoring of exit-site conditions and demonstrated effectiveness in reducing infection incidence. However, the REDS scale is clinician-administered and does not assess patient knowledge, beliefs, or self-efficacy, which are central to sustained behavioural adherence.

Educational interventions examined by Ibrahim *et al.,* [14] and Porażko *et al.,* [15] showed that structured patient engagement can significantly reduce CRBSI incidence. However, without a comprehensive patient-reported instrument, it remains difficult to determine which specific self-management behaviours contribute most to infection prevention or to systematically evaluate behavioural change following interventions.

4.3 Methodological Considerations: Limitations of CTT

A central methodological finding of this review is that all identified validation studies, including those validating general self-management instruments [2-4] and vascular access self-care tools [5,6,8,9], relied exclusively on Classical Test Theory methods. These studies reported satisfactory Cronbach's alpha coefficients and factor structures; however, CTT assumes equal item contribution and treats summed scores as linear measures.

Such assumptions may be inadequate for behaviour-specific constructs such as CRBSI self-management, in which behaviours vary substantially in complexity and difficulty. For example, although Lira et al. [8] reported acceptable internal consistency for the Brazilian adaptation of the AVF self-care scale, structural variations observed across cultural adaptations, including the emergence of a modified five-factor structure in the Turkish validation [11], suggest potential measurement variability that CTT-based analyses alone may not fully capture. Furthermore, CTT-based analyses do not provide item-level difficulty estimates or hierarchical ordering, limiting insight into which behaviours are most challenging for patients.

As illustrated in Figure 3, modern measurement approaches such as the Rasch Measurement Model offer advantages by transforming ordinal responses into interval-level measures and providing item-level diagnostics. The absence of Rasch or Item Response Theory analyses in the reviewed studies, therefore reflects a methodological gap rather than merely a reporting limitation.

4.4 Implications for Instrument Development and Research

The findings underscore the need to develop a CRBSI-specific, patient-reported self-management instrument validated using modern psychometric approaches. Such an instrument should integrate infection-related knowledge, behavioural practices, and psychosocial determinants, including self-efficacy and perceived barriers.

Applying Rasch analysis during instrument development would enable the identification of misfitting items, the verification of unidimensionality, and the establishment of behavioural hierarchy. This would facilitate the development of a clinically practical, psychometrically robust tool suitable for routine use in dialysis settings.

Future research should prioritise cross-cultural validation and formal testing of measurement invariance, particularly given the structural differences observed between the Taiwanese [3] and Turkish adaptations [4] of the HDSMI. Considering the global burden of CRBSI, ensuring equivalence across diverse haemodialysis populations is essential.

4.5 Clinical Implications

From a clinical perspective, the absence of a comprehensive CRBSI-specific self-management instrument limits systematic assessment of patient readiness for catheter care. While clinician-administered tools such as the REDS scale [15] support infection monitoring, they do not capture patient-reported behavioural competence.

Moreover, a Rasch-validated patient-reported instrument would enable clinicians to identify specific behavioural deficits and tailor education accordingly. Furthermore, linking patient-reported behavioural data with infection outcomes, as demonstrated in interventional studies [14,15], could inform evidence-based resource allocation toward high-impact prevention strategies.

4.6 Strengths and Limitations of the Review

This review employed a systematic search strategy guided by PRISMA principles and synthesised evidence across multiple geographical contexts. By explicitly examining psychometric methodology, this review provides insight beyond descriptive instrument comparison and advances methodological discussion within renal nursing research.

Nevertheless, the review was limited to published validation studies and may have excluded grey literature. Heterogeneity in reporting standards restricted direct statistical comparison across instruments. Additionally, because no Rasch-based validation studies were identified, empirical comparison between classical and modern measurement approaches was not possible.

5. Conclusions

Existing self-management and self-care instruments for haemodialysis patients demonstrate acceptable psychometric properties under CTT but lack the specificity and methodological rigour required to assess behaviours related to catheter-related bloodstream infection prevention comprehensively. Most available tools focus on general self-management or arteriovenous fistula care, while infection-specific instruments address only isolated behaviours or rely on clinician-administered assessments.

This review identifies a critical gap in the measurement of patient self-management for CRBSI prevention. It highlights the need for the development of a patient-centred, infection-specific instrument validated using the Rasch Measurement Model. Such an instrument would enable precise measurement, personalised education, and rigorous evaluation of interventions aimed at reducing the global burden of catheter-related infections among haemodialysis patients.

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