Review Article

Psychometric Properties of Questionnaire-Based Measurement of Immunosuppressant Knowledge in Kidney Transplantation: A Scoping Review

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ABSTRACT

Questionnaires are often used to evaluate the understanding of immunosuppressive therapy (IST) among kidney transplant recipients (KTR). This study investigated the psychometric properties of these questionnaires and their level of recommendation for use. Relevant articles were searched from PubMed, MEDLINE, CINAHL, Web of Science, Cochrane Library, and Scopus utilising the PRISMA Extension for Scoping Review protocol. Peer-reviewed and English-language articles that reported on the psychometric properties of questionnaires evaluating IST knowledge among KTR were considered relevant. The Consensus-based Standards for the Selection of Health Measurement Instruments (COSMIN) guidelines and the TERWEE tool were used to evaluate psychometrics for methodological quality, criteria for good measurement, level of evidence (LoE), and applicability. Of the 88 potential articles, 10 were deemed relevant. The articles comprised cross-sectional studies (n=7), tool validation studies (n=2), and studies that combined both methods (n=1). Content validity was described in 8 articles and presented as 'doubtful' in all of them; internal consistency in 8 articles and rated 'very good' (n=6) and 'doubtful' (n=2); structural validity in 2 and both were rated 'adequate'; reliability in 4 and rated 'very good' (n=2) and 'doubtful (n=2), hypothesis testing in 3 with 'very good (n=2) and 'adequate' (n=1) ratings; and responsiveness in one article rated as 'adequate. The criteria for most properties were classified between 'indeterminate' and 'adequate'; with a 'moderate LoE.' All questionnaires received grade B recommendations. Existing questionnaires lack validity and reliability, necessitating future research to develop questionnaires with appropriate constructs to accurately assess knowledge about IST among KTR.

Keywords: Kidney transplantation, Patient medication knowledge, Healthcare surveys

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1.0 Introduction

One of the key successes of kidney transplantation is the appropriate use of immunosuppressant therapy (IST) (1). In most countries, kidney transplant recipients (KTR) are commonly maintained on triple IST consisting of calcineurin inhibitors, antiproliferative agents, and corticosteroids (1). The balance between insufficient and excessive immunosuppressive effects plays a crucial role in preventing graft rejection, life-threatening opportunistic infections, immunosuppressive therapy toxicity, and graft failure (1,2). Patients' inability to comprehend IST administration instructions can pose a significant risk for self-induced medication errors, adverse side effects, and non-adherence to prescribed treatment (3).

Approximately 20% of KTR experience mood and anxiety disorders due to adverse effects from medication, difficulty in understanding dosage schedules, and post-transplant complications (3,4). Additionally, the high pill burden and intricate regimen schedules, including multiple dosing, diverse dosage forms, and frequent dosage adjustments, can pose cognitive difficulties for KTR in comprehending treatment requirements (1,4,5). These situations may lead to difficulties in medication adherence. Unlike other chronic conditions, nonadherence to IST in kidney transplantation can result in treatment failure, necessitating dialysis resumption (6,7). Previous research has demonstrated that an adequate understanding of IST among organ transplant recipients is linked to favourable outcomes in various domains, including health and medication literacy (7–10). This insight has been found to play a crucial role in preventing errors and reducing the risk of complications associated with medications (8,9,11).

In response to this requirement, transplant-specific questionnaires were developed to gauge patients' understanding of IST, as well as post-transplant self-management, quality of life, and importance of compliance towards medication regimens. The questionnaire is the preferred instrument for assessing knowledge about IST in research and clinical practise because of its proven effectiveness in obtaining prompt and comprehensive patient-reported outcomes (12). In addition to its value in developing customised interventions based on each patient's unique needs, this approach also facilitates better communication between patients and healthcare providers (12–14).

Nevertheless, data on the validity of transplant-specific questionnaires' psycho-metric properties in measuring patients' comprehension of transplant medications is scarce. This study aimed to examine the psychometric properties of questionnaires used to report on KTRs' knowledge about IST and their level of recommendation for use in research and clinical settings. The findings of this study offer valuable input for the development, validation, and improvement of assessment tools for medication management after transplantation.

2.0 Methods

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Extension for Scoping Review was used to perform and report on this study (15). The flow of the literature search is shown in Figure 1. Two reviewers were involved in data collection (NSS and NI) and cross-checked by a third reviewer (MSAW). The three reviewers discussed any discrepancies and disagreements in team meetings and reached a consensus on how to resolve them. All reviewers contributed to the design and final reporting of this review. Because of the nature of scoping reviews, ethical approval is not required.

2.1 Eligibility Criteria

Peer-reviewed articles in English that met the following criteria were considered eligible: (a) interventional, observational, or tool validation studies; (b) involving kidney transplant recipients aged 18 years or older; (c) reported on questionnaires for assessing

knowledge of IST; and (d) provided information on the psychometric properties of the questionnaires. Editorials, reviews, and conference abstracts were excluded.

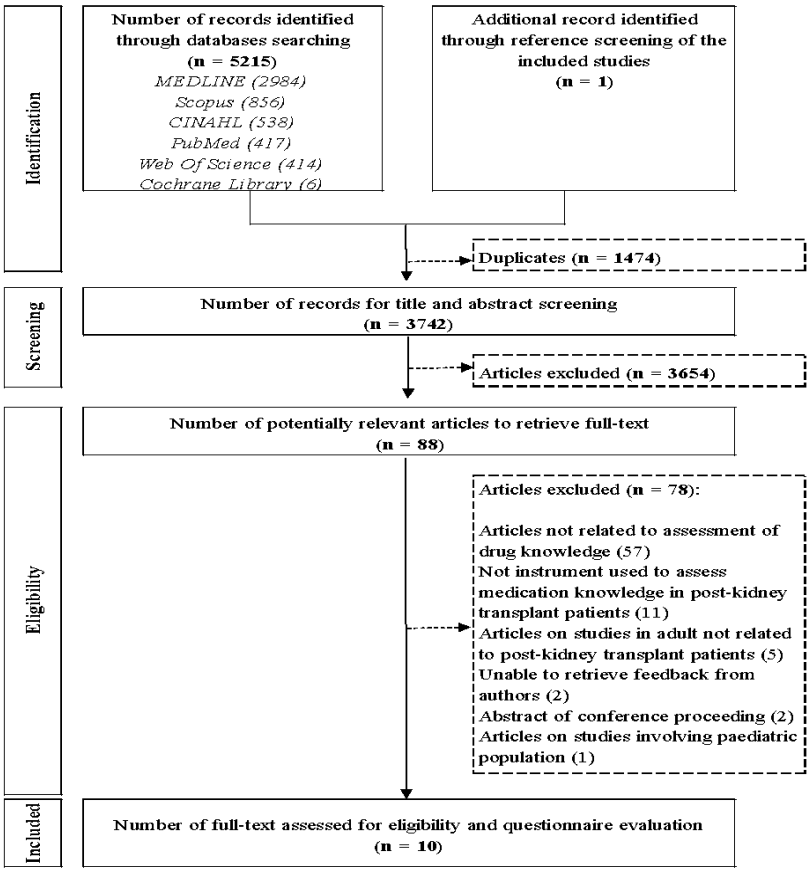

Figure 1: Flow diagram of literature search

Table 1: Example of PubMed Search Strategy.

PubMed	
#1	"kidney transplantation"[MeSH Terms] OR "renal transplant*"[Title/Abstract] OR "kidney transplant*"[Title/Abstract] OR "renal graft*"[Title/Abstract] OR "kidney graft*"[Title/Abstract] OR "kidney allograft*"[Title/Abstract] OR "renal allograft*"[Title/Abstract] OR "nephrectom*"[Title/Abstract]
#2	"surveys and questionnaires"[MeSH Terms] OR "health care surveys"[MeSH Terms] OR "questionnaire*"[Title/Abstract] OR "survey*"[Title/Abstract] OR "instrument*"[Title/Abstract] OR "tool*"[Title/Abstract] OR "measure*"[Title/Abstract] OR "scale*"[Title/Abstract] OR "evaluation*"[Title/Abstract] OR "assessment*"[Title/Abstract] OR "indicator*"[Title/Abstract]
#3	"patient medication knowledge"[MeSH Terms] OR "health literacy"[MeSH Terms] OR "health knowledge, attitudes, practice"[MeSH Terms] OR "medication knowledge"[Title/Abstract] OR "therap* knowledge"[Title/Abstract] OR "health knowledge"[Title/Abstract] OR "knowledge gap"[Title/Abstract]
#4	"patient-reported outcome measures"[MeSH Terms] OR "patient reported outcome*"[Title/Abstract] OR "humanistic outcome*"[Title/Abstract] OR "self assessed outcome*"[Title/Abstract] OR "self report*"[Title/Abstract]
#5	#3 OR 4:
#6	#1 AND #2 AND #5
#7	Filters: **Humans, Adult: 19+, English**

2.2 Information Sources and Search Strategy

A comprehensive search of the literature was conducted from six databases: PubMed, MEDLINE, CINAHL, Web of Science, Cochrane Library, and Scopus, from inception until July 2022. The search terms were derived using keywords such as kidney transplant, medication knowledge, immunosuppressant, and assessment tools, which were then customised for each database. The search method of PubMed is illustrated in Table 1. Additional hand-selected articles were identified by searching the reference lists of relevant studies.

2.3 Article Selection and Data Extraction

The search results were entered into Mendeley Reference Manager software to delete duplicate articles. Two reviewers (NSS and NI) independently screened the titles and abstracts to identify potential articles. To be selected, the abstracts had to identify an evaluation of IST knowledge and involvement of kidney transplant recipients. The full-text articles of all remaining citations were obtained and assessed independently for eligibility by these 2 reviewers based on the defined inclusion criteria. Any disagreements were resolved through discussion between the 2 investigators and, if needed, consultation with a third author (MSAW). Data extraction was undertaken by a single reviewer (NSS) and was checked by a second (NI) and a third reviewer (MSAW).

The full text of articles that fulfilled the eligibility criteria were retrieved and extracted for the following purposes:

- Publication details (names of the authors, year of publication, and country of study)
- Study methods (study design, sample size, and study duration)
- Subject demography (age, gender, duration of post-transplant, and type of transplant)
- Questionnaire characteristics (name of the questionnaire, number of items, answer options, and completion time to answer)
- Questionnaires' psychometric information: content validity, internal consistency, reliability, measurement error, structural validity, construct validity, cross-cultural validity, criteria validity, and responsiveness.

2.4 Quality assessment of psychometric properties

The psychometric properties examined in this study are reliability, validity, and responsiveness (16). Validity refers to the extent to which a questionnaire accurately assesses the construct it claims to evaluate. The validation assessment components include content, structural, cross-cultural, hypothesis testing, and criterion validity. Responsiveness pertains to the extent to which questionnaire scores exhibit changes over a time frame, particularly in individuals who have experienced the desired alteration. Responsiveness measures the effectiveness of the questionnaire in measuring the desired outcome in terms of effect size or measurement (17).

A few examples of psychometric evaluation tools used to evaluate patient-reported outcomes and health status measurement instruments are the Scientific Advisory Committee of the Medical Outcomes Trust (SACMOT) tools, Evaluating the Measurement of Patient-Reported Outcomes (EMPRO), and Consensus-based Standards for the selection of health status measurement instruments (COSMIN) tools (18). A few important variables have contributed to the COSMIN tool's rise to popularity as the most frequently referenced. First, the model was developed through a rigorous Delphi study. Furthermore, the COSMIN tool is publicly available, facilitating extensive utilisation and accessibility (16). Researchers often use the COSMIN tool along with a separate tool developed by Terwee et al. (2007) (18) because while the COSMIN evaluates adherence to design standards, the latter

provides criteria for judging psychometric properties (15,18). The COSMIN tool includes a manual that provides clear instructions for data synthesis and outcome evaluation (18,19). It has 114 items, of which 96 relate to various psychometric properties (18). In the scope of this study, the COSMIN checklist (17) and the TERWEE tool (18) were used to evaluate psychometric properties. The evaluation method protocol has been extensively explained elsewhere (16,17,19) and simplified into the following four steps:

Step 1: Evaluation of 'methodological quality'
The methodological quality of each article was based on its psychometric properties and assigned ratings of 'very good', 'adequate', 'doubtful', and 'inadequate'.

Step 2: Rating the criteria of psychometric properties.
The results of each study on the psychometric properties were then graded against the criteria for good measurement properties and assigned ratings of 'sufficient, 'insufficient', 'indeterminate', or 'inconsistent'.

Step 3: Grading the evidence quality
Then, the quality of evidence for each psychometric property was assessed against the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) approach. The quality of evidence was graded as 'high', 'moderate', 'low', or 'very low' (19,20).

Step 4: Identify the most recommended questionnaire.
Finally, the applicability of each questionnaire in clinical or research settings was graded into one of the following three categories:

- *Category A:* Use of the questionnaire is highly recommended. The assessment exhibits satisfactory content validity and has achieved a minimal level of internal consistency.
- *Category B:* Further evaluation of the questionnaire's psychometric qualities is necessary before endorsing its use.
- *Category C:* Use of questionnaire is not recommended due to inadequate measuring properties.

3.0 Results

3.1 Article Characteristics

From a total of 5215 publications, 88 were potential. After obtaining the full text, a subset of 10 articles were identified as fitting the specified criteria for eligibility and then selected for evaluation (21–30), as shown in Figure 1. The articles included in this study addressed recipients at different time intervals after kidney transplantation, ranging from 5 days to 9 years. Seven of the articles were cross-sectional studies (21–23,25,27,29,30), two articles focused on the validation of questionnaires (24,26), and one study incorporated elements of both study types (28). The study with the widest sample size and longest duration was conducted in Germany for 26 months, with 702 participants (21). Table 2 summarises the key attributes exhibited by the articles deemed eligible for inclusion.

3.2 Characteristics of the questionnaire

The characteristics of the questionnaires are outlined in Table 3. The ten articles that were reviewed in this study collectively reported data from a total of 2,461 KTRs using ten questionnaires with the following names: Knowledge Test (KT) (21), Five-item Knowledge Subscale (FI-KS) (22), Beliefs About Medicines-Specific Questionnaires (BMQ-S) (23), Korean K-TUTk questionnaire (24), Perisan Self-Management Scale for Kidney Transplant Recipient (KTR-SMSp) (25), Self-Management Scale for Kidney Transplant Recipient (KTR-SMS) (26), Kidney Transplant Health Promotion Behaviour (KTHPB) (27), Kidney Transplant

Understanding Tools (K-TUT) (28), Transplantation Knowledge Questionnaire (TKQ) (29), and Immunosuppressant Medications Belief Questionnaire (IMBQ) (30). The Korean Kidney Transplant Understanding Tools (K-TUTk*)* (24) is the translation of the English K-TUT questionnaire (28). The Persian KTR-SMSp (25) was translated from the Japanese KTR-SMS questionnaire (26). Only the TKQ (29), KTUT (28) and KTUTk (24) questionnaires involved KTR in their development, with a sample size of no more than 10 each. Additionally, there was limited information on the involvement of the skilled interviewers and whether data collection continued until saturation was reached. Non-KTR patients participated in the development of the BMQS (23) and IMBQ (30) questionnaires, but no patients were involved in the development of the other five questionnaires, namely the KT, FI-KS, KTR-SMSp, KTR-SMS, and KTHPB (21,22,25–27). Of the 10 questionnaires, seven were developed for use in kidney transplant patients, namely the KT, KTUTk, KTR-SMS, KTR-SMSp, KTHPB, KTUT, and KTUTk questionnaires (21,24–29). The FI-KS, BMQS, and IMBQ questionnaires were developed for the general population and then modified for application in the context of kidney transplantation (22,23,25). The response options in the questionnaires included binary choices (yes/no), multiple-choice options, and Likert scale. There was no information in any article on how long patients took to complete the questionnaires.

3.3 Methodological quality assessment

Table 4 presents a summary of the methodological qualities used in the development of the questionnaires. None of the articles measured all psychometric properties listed in the COSMIN checklist during questionnaire development. Content validity and internal consistency were the most tested. Four of the 10 articles (40%) measured four psychometric properties (24–26,28). Two psychometric properties were measured in another four articles (40%) (22,27,29,30), and one property was measured in two articles (20%) (21,23). Three psychometric properties not assessed for the articles were cross-cultural validity, measurement error, and criterion validity. Content validity was reported in only eight articles, and all were rated ‘doubtful’ due to limited sample sizes, unclear data analysis, and a lack of patient involvement (22,24–30)

a. Structural validity was only reported for the KTR-SMS and KTR-SMSp questionnaires by exploratory factor analysis with a sufficient sample size and rated ‘adequate’(25,26).
b. Internal consistency was reported in eight articles, of which six utilised the following questionnaires—FI-KS, BMQS, KTR-SMSp, KTR-SMS, KTHPB, and IMBQ—measured subscale Cronbach’s alpha and received a ‘very good’ rating (20,23,25–27,30). Two articles that reported on the KTUTk and KTUT questionnaires were rated ‘doubtful’ due to exhibiting only the total internal consistency (24,28).
c. The reliability of the KTUTk and KTUT questionnaires received ‘very good’ ratings for reporting interclass correlation, Cohen’s kappa for dichotomous scores, adequate period, and evaluation under similar conditions (24,28). The KTR-SMS and KTR-SMSp were deemed ‘doubtful’ due to unclear test-retest conditions. (25,26)
d. Hypothesis testing was performed for the KTUT, KTUTk, and TKQ questionnaires (24,28,29). The KTUT and KTUTk questionnaire received ‘very good’ rating for demonstrating a significant correlation between health literacy and the instrument’s total knowledge score (KTUT: $r=0.52$, $P<0.05$; KTUTk: $r=0.57$, $P<0.001$).
e. Responsiveness was reported only for the KT questionnaire (21) by evaluating the association between knowledge level and subgroup variables. Its ability to detect significant changes over time was rated

'adequate' due to small effect sizes. Although the effect sizes were relatively small, the results revealed a positive link between knowledge levels and several demographic factors. These include gender (specifically being female), relationship status (specifically being in a committed relationship), first language (specifically speaking German), and cognitive ability (specifically having better cognitive function).

3.4 Rating the psychometric properties and evidence level of the questionnaires

Table 5 summarises the rating of the criteria for good psychometric properties and the level of evidence.

a. Content validity was rated as 'inconsistent' in six articles (24–29) and 'indeterminate' in two articles (22,30) due to small sample numbers, unclear data analysis, and a lack of patient involvement in the methodological quality, as mentioned earlier. The degree of evidence ranged from moderate to very low, given the lack of studies to establish the content validity of the questionnaires.
b. The structural validity of the two articles involving the KTR-SMS and KTR-SMSp questionnaires did not fulfil the criteria for COSMIN's good measurement properties and were rated 'indeterminate'(25,26).
c. The internal consistency of two articles that used the KTR-SMSp and KTR-SMS questionnaires was rated 'sufficient' (25,26). There was a strong level of evidence supporting this rating, as the factor analysis revealed Cronbach's alpha values greater than 0.70. However, six more articles that mentioned the FIKS, BMQS, KTHPB, IMBQ, KTUT, and KTUTk questionnaires were classified as 'indeterminate' since they missed out on internal consistency testing and had low to very low-quality evidence (22–24,27,28,30).
d. Reliability measurements of four articles using the KTR-SMS, KTUTk, KTUT, and KTR-SMSp questionnaires were graded 'sufficient' (24–26,28). However, the KTR-SMS and KTR-SMSp questionnaires provide higher evidence levels than the K-TUT.
e. Hypothesis testing was reported in three articles on the KTUT, KTUTk, and TKQ questionnaires (24,28,29). The psychometric properties tests of all three questionnaires were supported by significant statistical correlations, satisfying the requirements for a 'sufficient' rating. Additionally, the evidence of a moderate quality level indicated that there was no structural equation modelling across scales to quantify variations between related constructs.
f. Responsiveness was reported in the KT questionnaire and was rated as 'sufficient'. This rating was based on its evaluation of the association between knowledge level and subgroup factors. The evidence level is considered moderate and can be enhanced by conducting confirmatory factor analysis or structural equation modelling across different scales for a more precise measurement of variances between related constructs.

3.5 Questionnaire categories of recommendations for use

None of the articles in this review met the standards for adequate content validity or exhibited low-quality evidence in terms of satisfactory internal consistency. All questionnaires included in this review were classified under category B, indicating that further evaluation of the psychometric qualities of the questionnaires is necessary before their use. The results are presented in Table 5.

Table 2: Characteristics of reviewed articles.

Author, year, country	Questionnaire (Language)	Study Design	Study duration/setting	Sample Size	Age (years)	Gender	Duration of transplantation	Transplant Type
de Boer et al. 2020, Germany (21)	KT (Germany)	Cross-sectional study	26 months/ Transplant centres in university hospitals	702	52.4 ± 14.2	Male 58.1% Female 41.9%	65.1 (69.2) months	70.5% deceased donor 29.5% living donors
Du et al. 2018, China (22)	FI-KS (Chinese)	Cross-sectional study	2 months/ transplant follow-up clinics	195	42.31 ± 11.31	Male 67.7% Female 32.3%	5.13 ± 4.92 years	95.4% deceased donor 4.6% living donors
Griva et al. 2012, United Kingdom (23)	BMQS (English)	Cross-sectional study	nd/2 transplant centres	218	49.7± 12.28	Male 59.6% Female 40.4%	5.78 ± 5.21 years	nd
Kang and Jeong 2020, South Korea (24)	K-TUT (Korean)	Methodological study design to construct and validate the Korean version of the K-TUT	nd/Transplant centres and outpatient clinics in university hospitals	92	49.9	Male 64.8% Female 35.2%	<1 year - 43.3% 1- 4.9 years - 26.7% 5 years or more - 30%	nd
Khezerloo et al. 2019, Iran (25)	KTR-SMS (Persian)	Cross-sectional study	5 months/ Transplant centre	360	47.01 ± 11.79	Male 44.4% Female 55.6%	< 2 years - 23.9% 2 - 4 years - 38.9% 4 - 6 years - 29.2% > 6 years -8.0%	nd

Author, year, country	Questionnaire (Language)	Study Design	Study duration/setting	Sample Size	Age (years)	Gender	Duration of transplantation	Transplant Type
Kosaka et al. 2013, Japan (26)	KTR-SMS (Japanese)	Methodological study design to construct, validate, and clinically test KTR-SMS	3 months in 3 hospitals	239	50.0 ± 11.7	Male 62.3% Female 37.7%	98.6 ± 91.7 months	23.9% deceased donor 75.3% living donors 0.8% both
Lin et al. 2011, Taiwan (27)	KTHPB (Chinese)	Cross-sectional study	4 months/ outpatient clinics	141	46.6 ± 11.0	Male 48.5% Female 51.5%	2.6 ± 1.4 years	44.6% deceased donor 34.7% living donors 20.8% unknown
Rosaasen et al. 2017, Canada (28)	K-TUT (English)	Phase 1: A stepwise iterative process (tool development) Phase 2: Cross-sectional study	Phase 1: nd Phase 2: 1 month Transplant clinic	Phase 1: 41 pre-transplant Phase 2: 148 post-transplant	55.1 ± 14.3	Male 55.4% Female 44.6%	Phase 2: <1 year - 3.4% >1-3 years - 8.1% >3-5 years - 8.1% >5-10 years - 22.3% >10 years, 58.1%	nd
Urstad et al. 2010, Norway (29)	TKQ (Norwegian)	Cross-sectional study	17 months/ Transplant centre	159	51.0 ± 14.0 years	Male 69% Female 31%	5 days	52.0% deceased donor 48.0% living donors
Xia et al. 2019, China (30)	IMBQ (Chinese)	Cross-sectional study	11 months/ outpatients at university hospital	208	43.7 years	Male 63.5% Female 36.5%	4.7 years (range 1-19 years)	70.2% deceased donor 29.8% living donors

(BMQ-Specific) Beliefs About Medicines-Specific Questionnaires, (FI-KS) Five-item Knowledge Subscale, (IMBQ) Immunosuppressant Medications Belief Questionnaire, (KTHPB) Kidney Transplant Heath Promotion Behaviour, (KT) Knowledge Test, (KTR-SMS) Self-Management Scale for Kidney Transplant Recipient, KTR-SMSk (Korean Self-Management Scale for Kidney Transplant Recipient), (K-TUT) Kidney Transplant Understanding Tools, (K-TUTp) Persian Kidney Transplant Understanding Tools, (TKQ) Transplantation Knowledge Questionnaire, (KTR) Kidney transplant recipients, (G) General population, (nd) no information.

Table 3: Characteristics of reviewed questionnaires.

Author, year, country	Questionnaires (Language)	Development method	Intended population	Types of questions	Number of questions	Score assessment
de Boer et al. 2020, Germany (21)	KT (Germany)	Focus group discussion/Interviews (Experts)	KTR	Closed-ended	8	Multiple-choice questions
Du et al. 2018, China (22)	FI-KS (Chinese)	*Translation from English version* [35]	G	Closed-ended	5	5-point Likert scale
Griva et al. 2012, United Kingdom (23)	BMQS (English)	Focus group discussion/Interviews (Non-KTR patients, Experts) Literature reviews	G	Closed-ended	10	5-point Likert scale
Kang and Jeong 2020, South Korea (24)	K-TUT (Korean)	*Translation from English version* [33]	KTR	Closed-ended	22	Yes/No and multiple-choice questions
Khezerloo et al. 2019, Iran (25)	KTR-SMS (Persian)	*Translation from Japanese* [33]	KTR	Closed-ended	24	4-point Likert scale
Kosaka et al. 2013, Japan (26)	KTR-SMS (Japanese)	Literature reviews	KTR	Closed-ended	24	4-point Likert scale
Lin et al. 2011, Taiwan (27)	KTHPB (Chinese)	Literature reviews	KTR	Closed-ended	18	5-point Likert scale
Rosaasen et al. 2017, Canada (28)	K-TUT (English)	Focus group discussions/interviews (KTR patients, Experts) Literature reviews	KTR	Closed-ended	22	Yes/No and multiple-choice questions
Urstad et al. 2010, Norway (29)	TKQ (Norwegian)	Focus group discussions/interviews (KTR patients) Literature reviews Contextualisation of another questionnaire that was used to assess patients with cancer for their knowledge of pain.	KTR	Close-ended	19	5-point Likert scale

Author, year, country	Questionnaires (Language)	Development method	Intended population	Types of questions	Number of questions	Score assessment
Xia et al. 2019, China (30)	IMBQ (Chinese)	Focus group discussion/Interviews (Non-KTR patients, Experts) Literature reviews	G	Closed-ended	15	5-point Likert scale

(BMQ-Specific) Beliefs About Medicines-Specific Questionnaires, (FI-KS) Five-item Knowledge Subscale, (IMBQ) Immunosuppressant Medications Belief Questionnaire, (KTHPB) Kidney Transplant Heath Promotion Behaviour, (KT) Knowledge Test, (KTR-SMS) Self-Management Scale for Kidney Transplant Recipient, KTR-SMSk (Korean Self-Management Scale for Kidney Transplant Recipient), (K-TUT) Kidney Transplant Understanding Tools, (K-TUTp) Persian Kidney Transplant Understanding Tools, (TKQ) Transplantation Knowledge Questionnaire, (KTR) Kidney transplant recipients, (G) General population, (nd) no information.

Table 4: Methodological quality of measurement properties.

Author, year, country	Questionnaire (Language)	Content Validity	Structural Validity	Internal Consistency	Cross-cultural Validity	Reliability	Measurement Error	Criterion Validity	Hypothesis Testing	Responsive-ness
de Boer et al. 2020, Germany (21)	KT (Germany)	nd	nd	nd	nd	nd	nd	nd	nd	Adequate
Du et al. 2018, China (22)	FI-KS (Chinese)	Doubtful	nd	Very Good	nd	nd	nd	nd	nd	nd
Griva et al. 2012, United Kingdom (23)	BMQS (English)	nd	nd	Very Good	nd	nd	nd	nd	nd	nd
Kang and Jeong 2020, South Korea (24)	K-TUT (Korean)	Doubtful	nd	Doubtful	nd	Very Good	nd	nd	Very Good	nd
Khezerloo et al. 2019, Iran (25)	KTR-SMS (Persian)	Doubtful	Adequate	Very Good	nd	Doubtful	nd	nd	nd	nd
Kosaka et al. 2013, Japan (26)	KTR-SMS (Japanese)	Doubtful	Adequate	Very Good	nd	Doubtful	nd	nd	nd	nd
Lin et al. 2011, Taiwan (27)	KTHPB (Chinese)	Doubtful	nd	Very Good	nd	nd	nd	nd	nd	nd
Rosaasen et al. 2017, Canada (28)	K-TUT (English)	Doubtful	nd	Doubtful	nd	Very Good	nd	nd	Very Good	nd
Urstad et al. 2010, Norway (29)	TKQ (Norwegian)	Doubtful	nd	nd	nd	nd	nd	nd	Adequate	nd
Xia et al. 2019, China (30)	IMBQ (Chinese)	Doubtful	nd	Very Good	nd	nd	nd	nd	nd	nd

(BMQ-Specific) Beliefs About Medicines-Specific Questionnaires, (FI-KS) Five-item Knowledge Subscale, (IMBQ) Immunosuppressant Medications Belief Questionnaire, (KTHPB) Kidney Transplant Heath Promotion Behaviour, (KT) Knowledge Test, (KTR-SMS) Self-Management Scale for Kidney Transplant Recipient, KTR-SMSk (Korean Self-Management Scale for Kidney Transplant Recipient), (K-TUT) Kidney Transplant Understanding Tools, (K-TUTp) Persian Kidney Transplant Understanding Tools, (TKQ) Transplantation Knowledge Questionnaire, (KTR) Kidney transplant recipients, (G) General population, (nd) no information.

Table 5: Criteria Rating of Psychometric Properties (R), Level of Evidence Quality (LoE), and Recommendations for Use.

Author, year, country	Questionnaire (Language)	Content Validity		Structural Validity		Internal Consistency		Cross-cultural Validity		Reliability		Measurement Error		Criterion Validity		Hypothesis Testing		Responsiveness		Recommend-ation
		R	LoE	R	LoE	R	LoE	R	LoE	R	LoE	R	LoE	R	LoE	R	LoE	R	LoE	
de Boer et al. 2020, Germany (21)	KT (Germany)																	+	**M**	B
Du et al. 2018, China (22)	FI-KS (Chinese)	**?**	**VL**			**?**	**VL**													B
Griva et al. 2012, United Kingdom (23)	BMQS (English)					**?**	**VL**													B
Kang and Jeong 2020, South Korea (24)	K-TUT (Korean)	±	**M**			**?**	**L**			+	**L**					+	**M**			B
Khezerloo et al. 2019, Iran (25)	KTR-SMS (Persian)	±	**M**	?	**M**	+	**H**			+	**M**									B

Kosaka et al. 2013, Japan (26)	KTR-SMS (Japanese)	±	**M**	?	**M**	+	**H**			+	**M**								B
Lin et al. 2011, Taiwan (27)	KTHPB (Chinese)	±	**VL**			**?**	**VL**												B
Rosaasen et al. 2017, Canada (28)	K-TUT (English)	±	**M**			**?**	**L**			+	**L**					+	**M**		B
Urstad et al. 2010, Norway (29)	TKQ (Norwegian)	±	**M**				**NA**									+	**M**		B
Xia et al. 2019, China (30)	IMBQ (Chinese)	**?**	**VL**			**?**	**VL**												B

(R) Rating criteria for Good Psychometric Properties: (+) sufficient, (-) insufficient, (?) indeterminate, (±) inconsistent
(LoE) Level of evidence quality: (H) High, at least one content validity study of very good or adequate quality; (M) Moderate, at least one content study of doubtful quality OR only content studies of inadequate quality or no content studies AND questionnaire development study of very good or adequate quality; (L) Low, only content validity studies of inadequate quality or no content validity studies AND questionnaire development study of doubtful quality; (VL) Very low, only content validity studies of inadequate quality or no content validity studies AND questionnaire development study of inadequate quality
Recommendations: (A) highly recommended for use, sufficient evidence of content validity and internal consistency; (B) requires further evaluation of psychometric properties before use; (C) not recommended for use, high-level evidence for insufficient property measurement.

(BMQ-Specific) Beliefs About Medicines-Specific Questionnaires, (FI-KS) Five-item Knowledge Subscale, (IMBQ) Immunosuppressant Medications Belief Questionnaire, (KTHPB) Kidney Transplant Heath Promotion Behaviour, (KT) Knowledge Test, (KTR-SMS) Self-Management Scale for Kidney Transplant Recipient, KTR-SMSk (Korean Self-Management Scale for Kidney Transplant Recipient), (K-TUT) Kidney Transplant Understanding Tools, (K-TUTp) Persian Kidney Transplant Understanding Tools, (TKQ) Transplantation Knowledge Questionnaire, (KTR) Kidney transplant recipients, (G) General population

4.0 Discussion

Literacy about medications in kidney transplantation is commonly measured using questionnaires for the advantages of time, cost, and feasibility. The first question in this study was to determine the psychometric quality of questionnaires that were used to report medication knowledge for patients who underwent kidney transplantation. Additionally, this study also set out to determine the most recommendable questionnaire for the above purposes. In total, 10 articles correspond to 10 transplant-specific questionnaires. The COSMIN guidelines and recommendations established by the modified TERWEE tool were used to evaluate psychometric properties. None of the articles reviewed in this study presented a valid and reliable questionnaire to measure KTRs' understanding of their transplant medications.

The results of this study showed that content validity and internal consistency were the most measured properties, but none of the questionnaires had sufficient content validity and internal consistency. The results of our study are consistent with those of two previous studies that assessed the psychometric properties of questionnaires in patients with cervical cancer and rotator cuff dysfunction using the Terwee tool (31,32). Contrary to this, a systematic review of 12 questionnaires on heart failure found that 75% of their questionnaires had positive content validity, 41.7% had internal consistency and identified the Atlanta HF Knowledge Test as a promising tool (33). Another interesting finding was the lack of patient involvement in the development of questionnaires intended to capture information directly from the patients themselves. To ensure that questionnaires for patient-reported outcomes are pertinent, complete, and understandable, good content validity studies must involve experts, patients, and target groups. In the context of understanding medications, patient involvement is important to identify their perceptions, experiences, and concerns regarding how medications might affect their daily lives (34). Such information would not be identified by healthcare providers. It is possible that not many patients are willing to participate in qualitative research that requires commitment to interviews and discussions with healthcare providers. Patients may be unwilling to speak up in such circumstances due to their feelings of inferiority towards the healthcare providers, fear of judgmental reactions or not being taken seriously, and a lack of literacy in discussions (35,36). The present study found that out of the 10 articles reviewed, only three reported the involvement of both patients and experts in the development procedure (23,28,30). This result is in line with a study by Nair and Wilson (2019) that revealed only a small number of questionnaires on chronic renal disease that were already in use included patients in the tool's development (37).

This study also found a lack of attention to reporting measurement error, cross-cultural validity, and criterion validity. Given the changing medical conditions and IST use over time in kidney transplantation (1,2), measurement error evaluation should be considered, as it would show how error-free the measurement is in relation to changes in a patient's condition. Regarding cross-cultural validity, the two questionnaires translated from their original versions were not tested for suitability for local use (24,25). When using the questionnaire, it should be adapted to the local culture and translated into the correct context. A previous study showed that language and culture impact KTR health literacy (38). Some terms may be regarded as unsuitable or misinterpreted because of the diversity of cultures and languages. This is especially true in Malaysia, where there are different ethnicities, religions, and languages. Incorrect execution of cross-cultural adaptation could lead to misleading or inappropriate outcomes of what was intended. Our study confirmed the absence of a gold standard instrument for measuring the understanding of IST in KTR. This finding

could explain the absence of criterion validity, which is commonly due to the lack of a gold standard instrument for criterion validity testing (16–18). A validated and reliable questionnaire would potentially minimise the variability in reporting patients' level of understanding IST therapy in research and clinical practise. Thus, accurate information about KTR's understanding of IST can be obtained, further improving medication educational initiatives to strengthen KTR's knowledge and empower their self-management in managing complex IST medications. The use of the questionnaire can also help facilitate conversations between healthcare providers and patients regarding medication-related issues. This can increase revenue for KTR by participating in shared decision-making with healthcare providers regarding their treatment plan and further increase their adherence to IST.

This study found insufficient evidence to recommend regarding their medications. However, four questionnaires have the potential to be used in research or clinical settings with further improvement of their psychometric properties, namely the KTUT, KTUTk, KTR-SMS, and KTR-SMSp questionnaires (24–26,28). Further research can be conducted to improve the quality of the psychometric properties of the questionnaires mentioned above by involving sufficient number of kidney transplant patients. This would improve the quality of content validity and confirmatory factor analysis in addition to reporting on internal consistency testing. It can be argued that the "worst score counts" principle of COSMINS has minimised the possibility of identifying questionnaire items with adequate psychometric qualities. However, it is worth noting that the COSMIN checklist is more commonly used than other instruments. It also comes with a manual guide to minimise inter- and inter-rater variability during quality assessment (39).

The interpretation of these results requires caution. First, our review contained only articles published in English. Therefore, the findings are not as generalisable as they may seem. Additionally, relevant articles may have been overlooked during the search strategy or abstract review process. Second, the inconsistent use of terminology related to validity may have affected the comparison of data on validity across studies. Some studies may also not provide clear or sufficient information on measurement properties; thus, it is difficult to assess the quality of a questionnaire. Third, only published results were reviewed; there is a possibility that there are studies on IST questionnaires that have not been published and hence were not included in this review. Despite its limitations, this study undoubtedly contributes to our understanding of the adaptability of existing questionnaires used to report knowledge regarding transplant medication among kidney transplant recipients. The overall findings from this study raise the intriguing question of whether the KTR's understanding of IST is accurately reflected in the current transplant-specific questionnaires.

5.0 Conclusion

Existing transplant-specific questionnaires lack adequate evidence of validity and reliability for evaluating the understanding of transplant medications. Thus, there is a high possibility that the information on IST knowledge obtained from transplant-specific questionnaires does not accurately reflect KTR's actual understanding. Future studies should focus on developing an improved instrument for measuring patient-reported outcomes in managing medication for KTR. The information about the constructs and gaps identified in this study can serve as a basis for designing this new instrument.

Authorship contribution statement

NSS, NI, CSL, NANNS and MSAW: Conceptualisation, data curation, methodology and writing—review and editing. **NI and MSAW**: Formal analysis, funding acquisition,

software and supervision. **NSS, NI, CSL and MSAW**: Investigation. **NSS and NI**: Project administration and writing—original draft.

Conflicts of interest

The authors have no relevant financial or non-financial interests to disclose.

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