Annals of Clinical Epidemiology

ORIGINAL ARTICLE

Validation of a new instrument for measuring disease-specific quality of life: A pilot study among patients with chronic kidney disease and hyperkalemia

Shunichi Fukuhara[1,2], Hajime Yamazaki[1], Takafumi Wakita[3], John E. Ware Jr.[4,5], Jui Wang[6,7], Yoshihiro Onishi[7], Toshitaka Yajima[8], Kenei Sada[9,10], Yosuke Yamamoto[11], Yugo Shibagaki[12]

ABSTRACT

BACKGROUND

To prepare for a longitudinal study of the effects of potassium-lowering treatment on quality of life (QOL), we quantified the validity of a new disease-specific instrument for measuring QOL, using data from patients who had hyperkalemia (HK) due to chronic kidney disease (CKD) or chronic heart failure, and were also being treated with potassium binders (PBs).

METHODS

In this cross-sectional study, the participants were 98 patients at five outpatient clinics in Japan. The outcome measures were the Medical Outcomes Study 36-item short-form (SF-36), a widely used generic measure of QOL, and the Quality of Life Disease-specific Impact Scale (QDIS-7), a recently-developed disease-specific measure of QOL. Internal-consistency reliability was quantified, and factor analysis was done to confirm hypothesized QOL dimensions. Validation tests used two external criteria: CKD stage, and PB formulation. PB formulation was used because different formulations are associated with different degrees of patients' burden. Using a previously-described method, we computed the relative validity (RV) of the two measures.

RESULTS

Two factor scoring of the SF-36 and one factor scoring of the QDIS-7, as standardized from previous studies, were confirmed. The RVs showed that the QDIS-7 was much more valid than the SF-36, for discriminating between groups defined clinically (by CKD stage), and also between groups defined by PB formulation. Reliability was satisfactory: 0.73–0.95 for the SF-36 and 0.86 for the QDIS-7.

CONCLUSIONS

The QDIS-7 with CKD or PB attributions was more valid than the SF-36 for measuring the effects of CKD and of PB formulation on QOL.

KEY WORDS

hyperkalemia, potassium binders, quality of life, treatment burden, chronic kidney disease

[1] Section of Clinical Epidemiology, Department of Community Medicine, Graduate School of Medicine, Kyoto University
[2] Johns Hopkins Bloomberg School of Public Health, Department of Health Policy and Management
[3] Faculty of Sociology, Kansai University
[4] Tufts University
[5] John Ware Research Group Inc.
[6] College of Public Health, National Taiwan University
[7] Institute for Health Outcomes & Process Evaluation Research (iHope International)
[8] AstraZeneca K.K.
[9] Department of Clinical Epidemiology, Kochi Medical School
[10] Patient Driven Academic League (PeDAL)
[11] Department of Healthcare Epidemiology, School of Public Health, Graduate School of Medicine, Kyoto University
[12] Division of Nephrology and Hypertension, St. Marianna University of Medicine

Corresponding author: Hajime Yamazaki
Section of Clinical Epidemiology, Department of Community Medicine, Graduate School of Medicine, Kyoto University, Yoshida-konoe-cho, Sakyo-ku, Kyoto 606-8501, Japan
E-mail: yamazaki-myz@umin.ac.jp

Received: August 16, 2022
Accepted: September 4, 2022
J-STAGE Advance published date: September 29, 2022

No. 23003

INTRODUCTION

Hyperkalemia (HK) increases the risk of adverse clinical events [1–3] including fatal arrhythmias [4], and it can increase healthcare costs [5–7]. Potassium binders (PBs) are the most direct treatment option for chronic HK. Adverse effects of PBs include constipation and gastrointestinal disturbances [8]. For that reason, and also because PBs have an unpleasant odor and texture [9], patients are often reported to reduce or even to discontinue their intake of prescribed PBs [10]. In particular, since HK itself is usually not painful, patients may perceive potassium-lowering therapy as burdensome, which can decrease their quality of life (QOL). On the other hand, reducing or discontinuing the intake of prescribed PBs can result in poor control of serum potassium, which in turn can decrease their QOL.

In Japan, PBs are available in five forms: powder, granules, dry syrup, oral jelly, and oral liquid. The perceived burden of potassium-lowering therapy is likely to be related to the formulation of the PB. For example, it is reasonable to expect that ingesting 15 grams of a PB powder is more burdensome (i.e., has a greater negative effect on QOL) than ingesting an equal dose of PB formulated as a liquid or a jelly. Preliminary evidence is consistent with that expectation [11, 12]. Specifically, compliance with prescribed potassium-lowering treatment was reported to be higher when PBs were formulated not as granules, powder, or dry syrup, but rather as oral liquids [11] or jellies [12]. However, those previous studies involved very few patients and did not use validated instruments to measure treatment burdens. Thus, it is necessary to precisely measure the perceived burden of PB therapy, that is, to precisely measure the impact of PB therapy on the patients' QOL.

We plan to do a longitudinal study of the impact of PB therapy on QOL, but first we did this pilot study among CKD patients receiving PB therapy, to evaluate the validity of a new instrument for measuring their disease-specific QOL. Specifically, we compared the recently-developed 7-item QOL Disease-specific Impact Scale (QDIS-7) [13] with the very commonly used generic Medical Outcomes Study 36-item short-form (SF-36) [14]. The QDIS-7 can measure the impact of symptoms and also the impact of treatments. Unlike the content and the scoring of conventional disease-specific QOL scales, both the content and the scoring of the QDIS-7 are standardized across different treatments or health conditions. This is the first study in Japan to test the QDIS-7 among patients undergoing potassium-lowering treatment.

METHODS

RESEARCH DESIGN

We used cross-sectional data to evaluate and compare psychometric properties of the two QOL measures in patients treated with PB for HK. The study was approved by the Ethical Review Committee of each participating medical institution.

PARTICIPANTS

The participants were recruited at five outpatient departments of nephrology or cardiology in general hospitals in Japan, between July and November 2020. Outpatients aged 20 years old or older who were being treated with PBs for HK associated with chronic kidney disease (CKD) of Stage 3b or higher or chronic heart failure (CHF, ejection fraction ≤40% or NYHA class II to IV) were included. CKD and CHF were diagnosed by the attending physicians in the five outpatient departments. Data from 98 patients who were being treated with PBs were used. Written informed consent was obtained from each participant.

MEASUREMENT

As a generic QOL measure, we used the standardized physical and mental component summary scores (PCS and MCS) [15] of the SF-36 Health Survey [14]. Higher scores indicate better QOL.

The QDIS-7 comprises seven question-items to assess the QOL burden of a particular named health condition [13]. For example, one item says "In the past 4 weeks, how often did your [CONDITION] limit your physical activities such as walking or climbing stairs?". For this study the [CONDITION] was replaced with "chronic kidney disease" for testing hypothesis 1 below, and it was replaced with "drug treatment for hyperkalemia" for testing hypothesis 2 below. Similar to the SF-36, scores on the QDIS-7 were standardized [13]. Unlike SF-36 scores, higher QDIS-7 scores indicate worse QOL, that is, higher QDIS-7 scores indicate greater impact of the health condition or the treatment.

PSYCHOMETRIC PROPERTIES OF THE TWO QOL MEASURES

Factor structure

Based on previous studies by their developers, a two-factor summary generic measurement model was hypothesized for the SF-36 [16] and one-factor disease-

specific summary measurement model was hypothesized for the QDIS [13].

Independent confirmatory factor analyses were used [17] to confirm standardized scoring based on those two hypothesized models. The percent contribution of a second factor to the total variance should be large in two-factor summary models. In contrast, the percent contribution of a second factor to the total variance should be very small in one-factor models. For both measures and models, an absence of residual correlations greater than 0.20 controlling for those factors was taken as support for the model. Factor loadings (the extent to which a factor explains an item score) were computed and loadings greater than 0.4 were interpreted as substantial.

In those two confirmatory factor analyses, in order to evaluate fitness of the data to the models, we computed the root mean square error of approximation [18], the standardized root mean squared residual (SRMR) [19], and the comparative fit index [20]. For the root mean square error of approximation and the SRMR, values generally considered to be acceptable are less than or equal to 0.05, and for the comparative fit index they are greater than or equal to 0.95.

Reliability

We quantified internal-consistency reliability of the scores on the SF-36's eight domains and also the internal-consistency reliability of the scores on the QDIS-7, with values greater than 0.7 taken as indicating sufficient reliability.

Criterion-based validity

Hypothesis 1: We hypothesized that for measuring how QOL is affected by CKD, the QDIS-7 is more valid than the SF-36 (PCS & MCS). Specifically, we hypothesized that the QDIS-7 is better than the SF-36 for discriminating among three groups that are defined by CKD stage: stages 3b, 4, and 5.

Hypothesis 2: We hypothesized that for measuring how QOL is affected by potassium-lowering treatment, the QDIS-7 is more valid than the SF-36 (PCS & MCS). Specifically, we hypothesized that the QDIS-7 is better than the SF-36 for discriminating between two groups that differ in the "perceived burden" of potassium-lowering treatment. To test hypothesis 2, based on previous findings [11, 12], we compared the group comprising powder, granules, and dry syrup with the group comprising oral liquids and oral jellies.

To collect the data needed for testing those two hypotheses, each patient completed two versions of the QDIS-7 in the same survey questionnaire. One version of the QDIS-7 focused explicitly on the effects of CKD, and the other version focused explicitly on the effects of potassium-lowering treatment.

SF-36 PCS and MCS scores, and QDIS-7 scores were tabulated by CKD stage and by PB-formulation group. To test hypothesis 1, the scores were subjected to analysis of variance by CKD stage. To test hypothesis 2, the scores were subjected to analysis of variance by PB-formulation group. Relative validity (RV) was estimated for each group comparison as the ratio of the F statistics for SF-36 PCS, MCS, and QDIS-7 to compare their validity in discriminating across the three groups differing in CKD stage (to test hypothesis 1), and across the two groups differing in PB formulation (to test hypothesis 2). RV was computed by dividing the F-ratio from the analysis of variance for QDIS-7 by the F-ratio from the analysis of variance for the SF-36 PCS and MCS. An RV greater than 1.0 indicates in proportional terms the extent to which the QDIS-7 is more valid than the SF-36 PCS or MCS, as in previous psychometric [21] and clinical [22] studies.

STATISTICAL ANALYSIS

Continuous variables were summarized as means and standard deviations, categorical variables as frequencies and proportions. SAS 9.4 (Cary, NC, USA) was used for most of the analyses. Mplus 8.7 (Muthén & Muthén, CA, USA) was used for the confirmatory factor analysis.

RESULTS

PARTICIPANTS

Data from 98 patients were analyzed. The characteristics of the participants are shown in the first column of **Table 1**. The population was elderly, with a mean age over 73 years. The majority had CKD as their primary disease, with about 60% receiving a prescription for a renin-angiotensin-aldosterone system inhibitor. The mean serum potassium value at enrollment was 4.8 mEq/L, and 35% of the participants had a serum potassium value greater than 5.0 mEq/L.

Of the 98 participants, 82 had CKD and 16 had CHF. SF-36 PCS and QDIS-7 scores were available for all of them. The numbers of patients by CKD stage were 19 (23%), 30 (37%), and 33 (40%) for stages 3b, 4, and 5, respectively.

Details of the PB prescriptions are shown in **Table 2**. Calcium polystyrene sulfonate and sodium polystyrene sulfonate accounted for 82% and 18% of the prescriptions, respectively. The group comprising powders, granules, and dry syrups included 39 patients, and the group comprising oral liquids and oral jellies included 59

Table 1 Characteristics of the participants

Number of participants	98
Age [years]	73.1 (11.6)
Female	22 (22%)
Body mass index [kg/m^2]	24.1 (3.6)
Disease	
Chronic kidney disease	82 (84%)
Chronic heart failure	16 (16%)
Comorbidity	
Hypertension	89 (91%)
Diabetes mellitus	55 (56%)
*Number of comorbidities**	
0	28 (29%)
1	37 (38%)
2	21 (21%)
3 or more	12 (12%)
Treatment potentially causing hyperkalemia	
Renin-angiotensin-aldosterone system inhibitor (RAASi)	59 (60%)
Beta-blocker	38 (39%)
NSAID	20 (20%)
Treatment for hyperkalemia	
Potassium binder	98 (100%)
Serum potassium	
Serum potassium [mEq/L]	4.8 (0.4)
<5.0	64 (65%)
5.0–<5.5	28 (29%)
5.5–<6.0	6 (6%)
≥6.0	0 (0%)
QOL scores	
SF-36 PCS	42.5 (12.0)
SF-36 MCS	56.8 (8.0)
QDIS-7 for CKD or CHF	48.6 (5.7)
QDIS-7 for HK Treatment	45.8 (4.4)

Figures are mean (standard deviation) or number (proportion).
* Comorbidities listed in Charlson et al., 1987 but excluding each participant's main disease (chronic kidney disease or heart failure) were included.
CKD, chronic kidney disease; CHF, chronic heart failure; HK, hyperkalemia; NSAID, Non-Steroidal Anti-Inflammatory Drugs; SF-36, Medical Outcomes Study 36-item short-form; PCS, physical component summary scores; MCS, mental component summary scores; QDIS-7, 7-item QOL Disease-specific Impact Scale.

Table 2 Prescription of potassium binders

Compound	
Calcium polystyrene sulfonate	80 (82%)
Sodium polystyrene sulfonate	18 (18%)
Daily dose	
<10 g	58 (59%)
10 g	28 (29%)
15 g	12 (12%)
Formulation	
Powder	12 (12%)
Granule	3 (3%)
Dry syrup	24 (24%)
Oral jelly	35 (36%)
Oral liquid	24 (24%)

Figures are numbers (proportion).

patients. Thus, either an oral jelly [23] or oral liquid [24] was prescribed to 60% of the patients. All daily doses were less than or equal to 15 grams, which is the minimum recommended dose printed on the package inserts for Calcium polystyrene sulfonate and sodium polystyrene sulfonate.

PSYCHOMETRIC PROPERTIES OF THE SF-36 AND THE QDIS-7

Factor analysis

Confirmatory factor analysis (two-factor model) was conducted on the SF-36 scores (**Table 3**). The root mean square error of approximation was 0.123, the SRMR was 0.062, and the comparative fit index was 0.905. Among the residual correlations, one value exceeded 0.2.

The QDIS-7 was unidimensional: The first factor explained 60.8% of the variance. The factor loadings for each item were high, ranging from 0.58 to 0.88 (**Table 3**, right column). There were no residuals greater than 0.2. The root mean square error of approximation was 0.169, the SRMR was 0.062, and the comparative fit index was 0.784.

Correlations between scores on the two instruments

The correlation between QDIS-7 scores and PCS scores was −0.472, and the correlation between QDIS-7 scores and MCS scores was −0.544.

Reliability

For both instruments, reliability was high: The internal-consistency reliability of scores on the SF36 domains

Table 3 **Factor loadings for each item of SF-36 and QDIS-7**

SF-36			QDIS-7	
Item	Factor I*	Factor II*	Item	Factor I
Physical functioning	0.862		Quality of life	0.667
Role physical	0.864		Physical functioning	0.878
Bodily pain	0.583		Role functioning	0.875
Social functioning	0.721		Fatigue	0.745
General health		0.637	Social activity	0.675
Vitality		0.799	Emotional	0.717
Role emotional		0.718	Health outlook	0.577
Mental health		0.811		

* inter-factor correlation : 0.866
SF-36, Medical Outcomes Study 36-item short-form; QDIS-7, 7-item QOL Disease-specific Impact Scale.

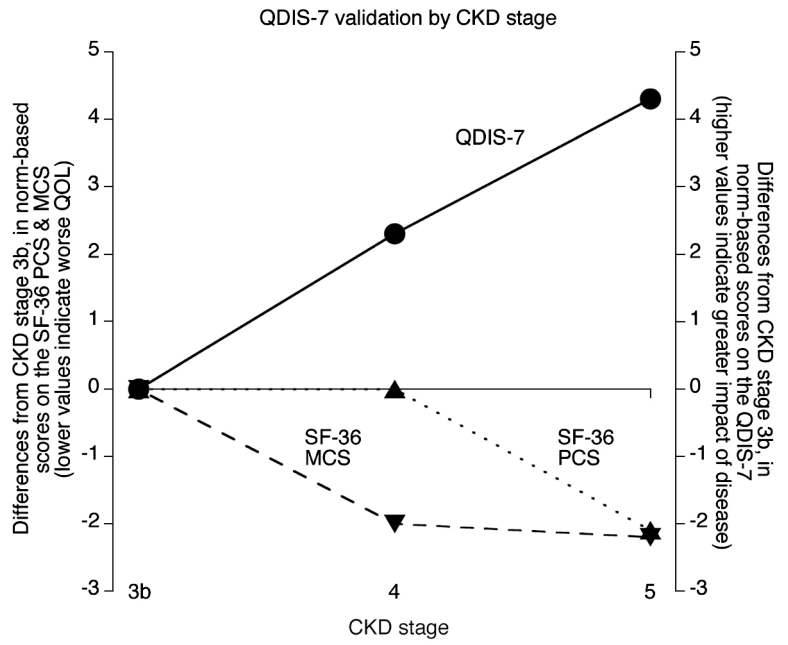

Fig. 1 **Performance of the QDIS-7 and the SF-36 in discriminating between groups differing in chronic kidney disease (CKD) stages. The graph shows the differences in the mean scores of the QDIS-7, and the SF-36 MCS and PCS for patients at CKD stages 4 and 5 relative to the scores for patients at stage 3b.**

ranged from 0.73 (Social Functioning) to 0.95 (Role-Emotional Functioning), and for the QDIS it was 0.86.

Criterion-based validity

Although both methods were valid, results of the test of hypothesis 1 (**Fig. 1**) showed that the QDIS-7 was more valid than the SF-36 PCS and MCS in discriminating between the groups differing in CKD stages (stages 3b, 4, and 5). The QDIS-7 was 13.9 times more sensitive to differences in CKD stage than was the SF-36 PCS, and it was 6.3 times more sensitive than was the SF-36 MCS.

Results of the test of hypothesis 2 showed that the QDIS-7 was more valid than the SF-36 PCS and MCS in discriminating between groups differing in "perceived burden" as represented by the two PB-formulation groups. The QDIS-7 was 15.0 times more sensitive to the differences between the two PB-formulation groups than

was the SF-36 PCS, and it was 1.2 times more sensitive than was the SF-36 MCS.

DISCUSSION

Although both methods were valid, testing using external criteria supported the two hypotheses: (1) Compared with the SF-36, the QDIS-7 was more sensitive to differences in the severity of CKD, and (2) the QDIS-7 was also more sensitive to differences in the patients' perceived burden of treatment with PBs.

Both the SF-36 and the QDIS-7 provide reliable scores. As expected, factor analysis showed that the SF-36 has two dimensions, physical and mental. Factor analysis also showed that the QDIS-7 has one dimension, which was also as expected.

The reliability and dimensionality results for the SF-36 are not surprising, given that the SF-36 has been widely used in many clinical settings worldwide for more than 20 years. In contrast, psychometric properties of the QDIS-7 are not well known, because the QDIS-7 was developed only recently [13], so the current study's results of psychometric testing are particularly important.

The psychometric results are important also because the QDIS-7 is unique among disease-specific QOL instruments. To make them sensitive to the impact of specific problems, and thus quite useful clinically, each traditional disease-specific QOL instrument has QOL content and item-response categories that are tailored to one disease [25]. In contrast, the QDIS-7 has the same item content and response categories for all health conditions or treatments – with the sole exception of the attribution, that is, the name of the disease, symptom, or treatment. Thereby, the QDIS-7 not only allows the condition's impact on QOL to be measured, but also allows that impact to be compared with the impact of other conditions, because it uses the same standardized metric and scoring across conditions. Thus, the QDIS-7 has the advantages of both generic and traditional disease-specific instruments. The present results also indicate that QDIS-7 scores can be summarized in a single score and interpreted as providing information about a respondent's location along a single dimension of health-condition impact or treatment impact.

For clinical validation of the QDIS-7, Ware *et al.* [13] used the SF-8 and the QDIS-7 to measure the burdens imposed on patients by various chronic conditions (CKD, low back pain, etc.), and the burdens imposed by conditions of various severities. Compared with the SF-8, the QDIS-7 was more sensitive to disease severity, with RV up to 20-fold better [13]. The result of the present study is similar to that of the previous study. The QDIS-7 was more sensitive than the SF-36 to differences in CKD severity.

The second clinical-validation test involved differences between PB-formulation groups. Treatment with PBs is burdensome due to its side effects and due to the inconvenience of taking PBs that are formulated as dry syrups, granules, or dry powders [26]. Also, the packaging of those PBs can be very bulky, which is cumbersome for patients who travel. This drives the need to evaluate PB-treatment burden, and to focus not only on taste and texture but also on decreased QOL. In Japan, PBs are now available not only in dry formulations but also as oral liquids [24] and jellies [23]. That allowed us to compare two groups receiving treatments known to differ in their compliance with prescribed treatment, apparently due to differences between the burden imposed by oral liquids or jellies and that imposed by powders, granules, and dry syrups.

While oral liquid and jelly formulations can improve compliance [11, 12], physicians are aware of the burdens of all types of PB therapy. Given the fact that the highest dose prescribed to any patient in this study was the lowest recommended dose (15 grams), it is clear that physicians in Japan tend to prescribe low doses. They might do so in response to patients' complaints, hoping that patients given lower doses will be more likely to continue taking the drug. Even with physicians prescribing low doses to decrease patients' burden, the current study's findings suggest that the QDIS-7 is likely to be better than the SF-36 at detecting the small differences in burden that were associated with different PB-formulation groups. We are therefore confident in proceeding to a larger-scale longitudinal study of the effects of PB formulation on QOL, provided that the outcome measures in that study include the QDIS-7.

CONCLUSIONS

The QDIS-7 is more sensitive than the SF-36 to the effects of CKD stage on QOL, and it is more sensitive to the perceived burden of PB therapy.

CONFLICTS OF INTEREST STATEMENT

TW and YY have act as consultants for the Institute for Health Outcomes & Process Evaluation research. Under contracts between Kyoto University and the Institute for Health Outcomes & Process Evaluation research, fees for consulting with HY and SF were paid to Kyoto University. JWang and YO

are employees of the Institute for Health Outcomes & Process Evaluation research. TY is an employee and a stock holder of AstraZeneca K.K. JWare received consulting fees from AstraZeneca K.K. YS has received honoraria from AstraZeneca K.K., Otsuka Pharma Co. and Kyowa Kirin Co. KS is a member of the speakers' bureau of Glaxo Smith Kline K.K.

ACKNOWLEDGMENTS

This study was supported by a grant from AstraZeneca K.K. We thank Joseph Green for comments and suggestions on an earlier version of the manuscript, and Christopher Holmes for editorial advice.

REFERENCES

1. Kashihara N, Kohsaka S, Kanda E, Okami S, Yajima T. Hyperkalemia in real-world patients under continuous medical care in Japan. *Kidney Int Rep* 2019;4:1248–60.
2. Einhorn LM, Zhan M, Hsu VD, Walker LD, Moen MF, Seliger SL, et al. The frequency of hyperkalemia and its significance in chronic kidney disease. *Arch Intern Med* 2009;169:1156–62.
3. Kohsaka S, Okami S, Kanda E,Kashihara N, Yajima T. Cardiovascular and Renal Outcomes Associated with Hyperkalemia in Chronic Kidney Disease: A Hospital-Based Cohort Study. *Mayo Clin Proc Innov Qual Outcomes* 2021;5:274–85.
4. Kovesdy CP, Appel LJ, Grams ME, Gutekunst L, McCullough PA, Palmer BF, et al. Potassium homeostasis in health and disease: a scientific workshop cosponsored by the National Kidney Foundation and the American Society of Hypertension. *Am J Kidney Dis* 2017;70:844–58.
5. Betts KA, Woolley JM, Mu F, Xiang C, Tang W, Wu EQ. The Cost of Hyperkalemia in the United States. *Kidney Int Rep* 2017; 3:385–93.
6. Kim K, Thomsen RW, Nicolaisen SK, Hasvold LP, Palaka E, Sørensen HT. Healthcare resource utilisation and cost associated with elevated potassium levels: a Danish population-based cohort study. *BMJ Open* 2019;9:e026465.
7. Kanda E, Kashihara N, Kohsaka S, Okami S, Yajima T. Clinical and Economic Burden of Hyperkalemia: A Nationwide Hospital-Based Cohort Study in Japan. *Kidney Med* 2020;2:742–52.
8. Harel Z, Harel S, Shah PS, Wald R, Perl J, Bell CM. Gastrointestinal adverse events with sodium polystyrene sulfonate (Kayexalate) use: a systematic review. *Am J Med* 2013; 126:264.e269–224.
9. Zann V, McDermott J, Jacobs JW, Davidson JP, Lin F, Korner P, et al. Palatability and physical properties of potassium-binding resin RDX7675: comparison with sodium polystyrene sulfonate. *Drug Des Devel Ther* 2017;11:2663–73.
10. Japan Health Sciences Foundation, Ministry of Health, Welfare, and Labour. Future perspective of CKD treatment. 2012 [Japanese].
11. Takei S, Itahashi K, Moriyama Y, Nitta K. Clinical effectiveness of Kalimate® Liquid (in Japanese). *Shinryo to Shinyaku (Med Cons New-Remed)* 2013;50:849–52.
12. Takashima K, Mizuno Y, Arita K, Igarashi S, Ushioki Y. Comparative testing of Kalimate® and Argamate® Jelly in hemodialysis patients (in Japanese). *Jpn J Pharm Health Care Sci* 2004;30:584–7.
13. Ware JE Jr, Gandek B, Guyer R, Deng N. Standardizing disease-specific quality of life measures across multiple chronic conditions: development and initial evaluation of the QOL Disease Impact Scale (QDIS®). *Health Qual Life Outcomes* 2016;14:84.
14. Ware JE Jr, Sherbourne CD. The MOS 36-item short-form health survey (SF-36). I. Conceptual framework and item selection. *Med Care* 1992;30:473–83.
15. Fukuhara S, Ware JE Jr, Kosinski M, Wada S, Gandek B. Psychometric and clinical tests of validity of the Japanese SF-36 Health Survey. *J Clin Epidemiol* 1998;51:1045–53.
16. Ware JE Jr, Kosinski M, Bayliss MS, McHorney CA, Rogers WH, Raczek A. Comparison of methods for the scoring and statistical analysis of SF-36 Health Profile and Summary Measures: Summary of results from the Medical Outcomes Study [abstract]. *Med Care* 1995;33:AS264.
17. de Boer AG, Spruijt RJ, Sprangers MA, de Haes JC. Disease-specific quality of life: is it one construct? *Qual Life Res* 1998;7:135–42.
18. Steiger JH. Structural model evaluation and modification: An interval estimation approach. *Multivariate Behav Res* 1990;25: 173–80.
19. Asparouhov, T, Muthén, B. SRMR in Mplus. Technical appendix. Los Angeles, US: Muthén & Muthén 2018.
20. Bentler PM. Comparative fit indexes in structural models. *Psychol Bull* 1990;107:238.
21. McHorney CA, Ware JE Jr, Raczek AE. The MOS 36-Item Short-Form Health Survey (SF-36): II. Psychometric and clinical tests of validity in measuring physical and mental health constructs. *Med Care* 1993;31:247–63.
22. Ware JE Jr, Richardson MM, Meyer KB, Gandek B. Improving CKD-specific patient-reported measures of health-related quality of life. *J Am Soc Nephrol* 2019;30:664–77.
23. SANWA KAGAKU KENKYUSHO CO., LTD. Package insert of CALCIUM POLYSTYRENE SULFONATE Oral Jelly "SANWA" (in Japanese). Available from:https://med.skk-net.com/supplies/generic/products/item/PSCJ2204.pdf, Accessed on Jan 2, 2022.
24. Kowa Company, Ltd. Package inseart of Kalimate® Oral Solution 20% (in Japanese). Available from:https://medical.kowa.co.jp/asset/item/17/4-pt_162.pdf, Accessed on Jan 2, 2022.
25. Wiebe S, Guyatt G, Weaver B, Matijevic S, Sidwell C. Comparative responsiveness of generic and specific quality-of-life instruments. *J Clin Epidemiol* 2003;56:52–60.
26. Palmer BF, Carrero JJ, Clegg DJ, Colbert GB, Emmett M, Fishbane S. Clinical Management of Hyperkalemia. *Mayo Clin Proc* 2021; 96:744–62.