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ORIGINAL ARTICLE

Validation of Patient-Reported Outcomes Measurement Information System Short Forms for Use in Childhood-Onset Systemic Lupus Erythematosus

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Objective. **To validate the pediatric Patient-Reported Outcomes Measurement Information System short forms (PROMIS-SFs) in childhood-onset systemic lupus erythematosus (SLE) in a clinical setting.**

Methods. **At 3 study visits, childhood-onset SLE patients completed the PROMIS-SFs (anger, anxiety, depressive symptoms, fatigue, physical function-mobility, physical function-upper extremity, pain interference, and peer relationships) using the PROMIS assessment center, and health-related quality of life (HRQoL) legacy measures (Pediatric Quality of Life Inventory, Childhood Health Assessment Questionnaire, Simple Measure of Impact of Lupus Erythematosus in Youngsters [SMILEY], and visual analog scales [VAS] of pain and well-being). Physicians rated childhood-onset SLE activity on a VAS and completed the Systemic Lupus Erythematosus Disease Activity Index 2000. Using a global rating scale of change (GRC) between study visits, physicians rated change of childhood-onset SLE activity (GRC-MD1: better/same/worse) and change of patient overall health (GRC-MD2: better/same/worse). Questionnaire scores were compared in support of validity and responsiveness to change (external standards: GRC-MD1, GRC-MD2).**

Results. **In this population-based cohort ($n = 100$) with a mean age of 15.8 years (range 10–20 years), the PROMIS-SFs were completed in less than 5 minutes in a clinical setting. The PROMIS-SF scores correlated at least moderately (Pearson's $r \geq 0.5$) with those of legacy HRQoL measures, except for the SMILEY. Measures of childhood-onset SLE activity did not correlate with the PROMIS-SFs. Responsiveness to change of the PROMIS-SFs was supported by path, mixed-model, and correlation analyses.**

Conclusion. **To assess HRQoL in childhood-onset SLE, the PROMIS-SFs demonstrated feasibility, internal consistency, construct validity, and responsiveness to change in a clinical setting.**

INTRODUCTION

Childhood-onset systemic lupus erythematosus (SLE) is a chronic autoimmune disease that often negatively impacts health-related quality of life (HRQoL), especially when permanent disease damage, increased disease activity, and fatigue are present (1–4). Traditional disease measures or physician assessment of disease activity have proven insufficient to accurately assess the impact of childhood-onset SLE disease on patient HRQoL (5). Therefore, various patient-reported outcomes (PROs) have been developed and validated in childhood-onset SLE to provide complementary information in support of optimal patient management and heightened satisfaction with care (6,7).

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Significance & Innovations

- The pediatric Patient-Reported Outcomes Measurement Information System short forms (PROMIS-SFs) demonstrated construct validity, internal consistency, and responsiveness to change in childhood-onset systemic lupus erythematosus (SLE).
- The PROMIS-SFs are easily completed in a clinical setting, thus decreasing the burden of health-related quality of life (HRQoL) measurement compared to currently used HRQoL legacy measures.
- Different from some HRQoL measures, the PROMIS-SFs did not correlate with overall childhood-onset SLE disease activity or damage.

Recently, the Patient-Reported Outcomes Measurement Information System (PROMIS), a publicly available system supported by the National Institutes of Health, has become available (http://nihpromis.org). PROMIS offers effective PRO measurement in various HRQoL domains, flexibility in administration of measures, and electronic data collection for both adult and pediatric populations. PROMIS aims at decreasing respondent burden and offering a comparison of PROs across disease groups, while improving the delineation of clinically relevant changes in HRQoL (8). To make full use of PROMIS to measure PROs in childhood-onset SLE, the pediatric PROMIS short forms (PROMIS-SFs) require validation to determine their measurement properties. The objectives of this study were to investigate feasibility, internal consistency, construct validity, and responsiveness to change of the PROMIS-SFs when used in childhood-onset SLE in a clinical setting.

MATERIALS AND METHODS

Study design and setting. This longitudinal study enrolled eligible childhood-onset SLE patients at 2 tertiary care centers (Cincinnati Children's Hospital Medical Center and Duke University Medical Center). Patients were consecutively recruited during routine clinic visits, between March 2012 and August 2014, and evaluated in 3-month intervals for up to 3 visits. At each visit, patients were asked to complete legacy HRQoL questionnaires in addition to the PROMIS-SFs; the treating physician rated disease activity, damage, and change of childhood-onset SLE severity and patient overall health between visits. Demographic data were obtained along with information collected as part of standard clinical care of childhood-onset SLE (medications, disease activity, duration, and damage) at each study visit.

Approval from local research ethics boards was obtained at each site. Prior to participation, the study was explained to each eligible patient and legal guardian, and written informed consent was obtained. Written assent was also obtained from participants ages ≤11 years. The study was conducted in accordance with the Declaration of Helsinki.

Study patients. Patients ages 8–20 years with a diagnosis of SLE prior to their 18th birthday (9), followed at a participating site, were approached to participate. Excluded were patients with a history of a comorbid chronic disease that might impact HRQoL besides childhood-onset SLE.

Pediatric PROMIS-SFs. Eight distinct HRQoL domains probed by the PROMIS-SFs were included in this study: anger ($PROMIS_{Anger}$), anxiety ($PROMIS_{Anxiety}$), depressive symptoms ($PROMIS_{Depression}$), fatigue ($PROMIS_{Fatigue}$), peer relationships ($PROMIS_{PeerRel}$), physical function-mobility ($PROMIS_{PF\text{-}Mobility}$), physical function-upper extremity ($PROMIS_{PF\text{-}UExt}$), and pain interference ($PROMIS_{Pain}$). Besides the $PROMIS_{Fatigue}$ (10 items) and $PROMIS_{Anger}$ (6 items), all other included PROMIS-SFs consist of 8 items each for a total of 64 items across 8 domains.

Each item included in the PROMIS-SFs has 5 ordinal response options, which consider the preceding 7 days. Response options for $PROMIS_{Anger}$, $PROMIS_{Anxiety}$, $PROMIS_{Depression}$, $PROMIS_{Fatigue}$, $PROMIS_{Pain}$, and $PROMIS_{PeerRel}$ are as follows: never, almost never, sometimes, often, and almost always, and for $PROMIS_{PF\text{-}Mobility}$ and $PROMIS_{PF\text{-}UExt}$: no trouble, with little trouble, with some trouble, with a lot of trouble, and not able to do. Additional details about PROMIS, definitions of domain framework, and domain profiles are provided elsewhere (10).

For each PROMIS-SF, a score can be calculated using either item response theory (IRT)–based response pattern scoring (preferred by PROMIS) or look-up tables that approximate the response pattern–based scoring. We used IRT scoring (11,12), with scores reported as T scores with normative mean values of 50 and SDs of 10. Additional information is provided in the PROMIS scoring manuals (12).

The PROMIS-SF scores reflect the presence of the construct measured. Hence, lower scores correspond to better HRQoL for $PROMIS_{Anger}$, $PROMIS_{Anxiety}$, $PROMIS_{Depression}$, $PROMIS_{Fatigue}$, and $PROMIS_{Pain}$. Conversely, lower scores indicate lower HRQoL for $PROMIS_{PeerRel}$, $PROMIS_{PF\text{-}Mobility}$, and $PROMIS_{PF\text{-}UExt}$. The internal consistency of each PROMIS-SF when used in other pediatric populations achieved a Cronbach's alpha of ≥0.85 (13–16).

Patient- and parent-completed HRQoL legacy measures. The Pediatric Quality of Life Generic Core Scale 4.0 (PedsQL-GC) is a self-report tool, composed of 23 items divided among 4 domains that include physical, emotional, social, and school function. Internal reliability was $\alpha = 0.89$. The Pediatric Quality of Life Rheumatology Module 3.0 (PedsQL-RM) is similar to the PedsQL-GC but is relevant for children with rheumatic diseases and has 22 items across 5 domains that include pain and hurt, daily activities, treatment, worry, and communication. Internal validity for the PedsQL-RM ranged 0.75–0.86. For both the PedsQL-GC and PedsQL-RM, a form for children (ages 8–13 years) and teens (ages 14–18 years) was used for the age-appropriate patients. Items are rated on a 5-point scale (where 0 = never and 4 = almost always), and from the raw scores a summary score of 0 to 100 can be calculated, with higher scores representative of better HRQoL.

The functional disability inventory (FDI) is a self-report measure that evaluates difficulty in physical and psychological function due to physical health. The instrument

has 15 items that evaluate perception of activity limitations; total score is summed, with higher scores indicative of greater disability. FDI scores <12 reflect no or minimal disability, scores of 13–29 indicate moderate disability, and ≥30 shows severe disability (17). In previous studies Cronbach's alpha was 0.86–0.91 (18).

The Simple Measure of Impact of Lupus Erythematosus in Youngsters (SMILEY) is a 26-item, childhood-onset HRQoL questionnaire, specific for SLE, that features 4 domains: effect on self, limitations, social, and burden of SLE. Responses are reported with a 5-faces scale. Each score ranges 1–5 and the total score is transformed to a 1–100 scale, with higher values representative of better HRQoL, and an internal reliability of 0.9 in other childhood-onset SLE populations (19).

The Childhood Health Assessment Questionnaire (C-HAQ) is an adaptation of the Stanford Health Assessment Questionnaire for pediatric use, consists of 30 items, and measures physical function in 8 domains: dressing/grooming, arising, eating, walking, hygiene, reach, grip, and activities. Within each domain, degree of difficulty (where 0 = no difficulty, 1 = some difficulty, 2 = much difficulty, and 3 = unable to do), use of aids/devices, and requirement for personal assistance with tasks is assessed. The item with the highest score for any given area is used as the score for that domain. The domain scores are averaged without weighting to yield a single disability index score (0–3) (20). Internal reliability as measured by Cronbach's alpha was 0.94 (21).

The Child Health Questionnaire (CHQ-PF50) is parent proxy-report of generic health status. The CHQ-PF50 is a profile measure of 50 questions that measures 10 mental and physical domains, or subscales: physical functioning, bodily pain, general health perceptions, role/social limitations–physical, role/social limitations-emotional/behavioral, parent impact–time and parent impact–emotions, self-esteem, mental health, and general behavior. Each subscale score ranges 0–100, with higher scores representing better health status. Two scores, CHQ-physical summary and CHQ-psychosocial summary, are calculated by aggregation of the subscales. Scores are standardized to a mean of 50 and SD of 10, where higher scores reflect better health status (22). The internal reliability for domains and subscales ranges 0.65–0.96 (23).

All questionnaires were administered on a laptop computer after clinic check-in, and study visits were conducted by a trained clinical research coordinator. At the end of the clinic visit, the research coordinator would check the questionnaires for completion and perform debriefing with the study participant. All questionnaires used in this study are child self-report except the CHQ-PF50, which is parent proxy-report.

Traditional childhood-onset SLE measures. Disease damage was evaluated with Systemic Lupus International Collaborating Clinics/American College of Rheumatology Damage Index (SDI; range 0–47, where 0 = absence of damage) (24,25). Disease activity was measured using a physician global disease assessment (MD-global; a 10-point Likert visual analog scale, where 0 = inactive disease), the Systemic Lupus Erythematosus Disease Activity Index 2000 (SLEDAI-2K; range 0–105, where 0 = inactive disease) (26), and the British Isles Lupus Assessment Group index (BILAG) with alphabetical converted to numerical domain scores (A = 12, B = 8, C = 1, D = 0, and E = 0, where 0 = inactive disease) (27). While the SLEDAI-2K considers only objectively measurable findings with childhood-onset SLE, the BILAG score also includes subjective symptoms such as arthralgias and myalgias (28).

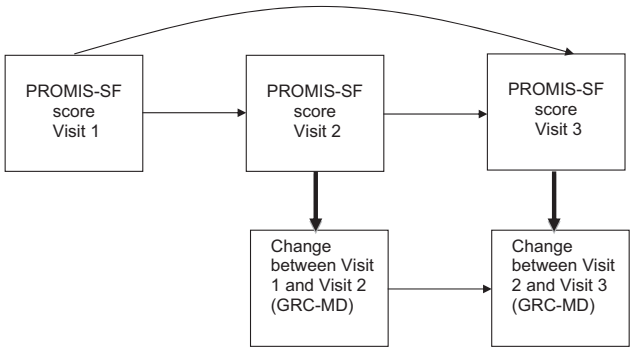

Figure 1. Path analysis model. Bold arrows are paths of interest and examine whether a Patient-Reported Outcomes Measurement Information System short form (PROMIS-SF) score at a given visit predicts change in childhood-onset systemic lupus erythematosus, using a physician's global rating scale (GRC-MD), rating both change and overall health status from the previous visit to the given visit.

Measures of childhood-onset SLE change. During the second and third visits, physicians used a global rating scale of change (GRC) to rate change in childhood-onset SLE severity (GRC-MD1) and overall health status (GRC-MD2), using 5-point Likert scales (much worse, somewhat worse, unchanged, somewhat better, and much better). GRC-MD1 and GRC-MD2, respectively, used the sentence stem "Has there been any change in your patient's lupus since his/her last study visit?" and "Has there been any change in your patient's overall health since his/her last study visit?"

Statistical analysis. Numerical variables were summarized by the mean ± SD, and binary and categorical variables were summarized by frequency and percentage. Feasibility was assessed by determining the proportion of patients who successfully completed the PROMIS-SFs (90% successful completion was considered feasible) along with measuring respondent burden as time (in minutes) needed for completion, along with a short, informal debriefing interview after completion to assess administration and understanding of PROMIS-SFs. We also assessed internal consistency of each of the PROMIS-SFs using Cronbach's alpha. We considered scores <0.5 unacceptable, 0.5–0.59 poor, 0.6–0.69 questionable, 0.7–0.79 acceptable, 0.8–0.89 good, and ≥0.9 excellent (29).

In support of construct validity (30,31), relationships between PROMIS-SF scores, HRQoL legacy measures, and traditional childhood-onset SLE measures (SLEDAI-2K, BILAG, MD-global, and SDI) were assessed with Pearson's correlation coefficient (r). Pooled or overall correlation coefficients (r_{pool}), using data from all visits and all patients, were estimated through a variance–covariance matrix, using a mixed-effect model (32) that adjusted for

Table 1. Demographics, childhood-onset SLE features, and PROs at visit 1 baseline (n = 100)*

Age, years	15.8 ± 2.2
Female, no. (%)	80 (80)
Race, no. (%)	
African American	48 (48)
White	33 (33)
Other†	19 (19)
Hispanic	8 (8)
SLEDAI-2K score	6.0 ± 5.9
BILAG score‡	6.4 ± 7.6
SDI score	0.4 ± 0.7
MD-global§	2.1 ± 1.7
Pediatric PROMIS short form domains	
Anger	51.1 ± 12.1
Anxiety	48.0 ± 11.0
Depressive symptoms	47.8 ± 11.9
Fatigue	50.7 ± 14.1
Mobility	46.9 ± 10.1
Upper extremity function	46.4 ± 7.90
Pain	50.3 ± 11.7
Peer relationships	49.7 ± 13.1
PedsQL-GC	70.6 ± 17.8
Physical function	68.9 ± 22.1
Emotional function	72.1 ± 20.9
Social function	79.9 ± 19.8
School function	62.9 ± 20.6
PedsQL-RM	74.4 ± 16.2
Pain and hurt	65.1 ± 28.0
Daily activity	86.7 ± 17.6
Treatment	76.9 ± 17.3
Worry	65.2 ± 25.3
Communication	69.6 ± 27.6
SMILEY	62.3 ± 13.9
Effect on self	56.2 ± 19.7
Limitations	68.3 ± 15.6
Social	64.1 ± 17.6
Burden of childhood-onset SLE	58.9 ± 18.3
Functional disability Inventory	8.4 ± 9.2
C-HAQ	0.47 ± 0.6
Dressing/grooming	0.36 ± 0.7
Arising	0.46 ± 0.7
Eating	0.33 ± 0.7
Walking	0.29 ± 0.6
Hygiene	0.32 ± 0.7
Reach	0.64 ± 0.8
Play	0.82 ± 0.9
Grip	0.57 ± 0.8
CHQ-PF50	
Psychosocial summary score	50.4 ± 10.6
Physical summary score	40.9 ± 12.5
Physical functioning	50.4 ± 25.5
Bodily pain	67.1 ± 25.8
General health perception	53.5 ± 17.0
Role/social-physical	82.8 ± 25.6
Role/social-emotional/ behavioral	80.4 ± 28.6
Parent impact–time	76.1 ± 29.1
Parent impact–emotional	63.4 ± 29.8
Self-esteem	79.2 ± 19.8
Mental health	78.5 ± 17.3
Behavior	80.0 ± 17.7

* Values are the mean ± SD unless indicated otherwise. All questionnaires are child self-report except Child Health Questionnaire P50 (CHQ-PF50), which is parent proxy-report. SLE = systemic lupus erythematosus; PROs = patient-reported outcomes; SLEDAI-2K = Systemic Lupus Erythematosus Disease Activity Index 2000; BILAG = British Isles Lupus Activity Group index; SDI = Systemic Lupus International Collaborating Clinics/American College of Rheumatology Damage Index; MD-global = physician global disease assessment; PROMIS = Patient-Reported Outcomes Measurement Information System; PedsQL-GC = Pediatric Quality of Life Generic Core Scale 4.0; PedsQL-RM = Pediatric Quality of Life Rheumatology Module 3.0; SMILEY = Simple Measure of Impact of Lupus Erythematosus in Youngsters; C-HAQ = Childhood Health Assessment Questionnaire.
† Another option for completion of the questionnaires if the provided choices did not apply or there was an overlap of the choices.
‡ Where A = 12, B = 8, C = 1, D = 0, E = 0.
§ On a 10-point Likert scale, where 0 = inactive disease.

dependency of observations. A correlation coefficient (r or r_{pool}) is considered low, fair, moderate, high, and very high if its estimated value is <0.3, 0.30–0.49, 0.50–0.69, 0.70–0.89, and ≥0.9, respectively (33).

In measuring responsiveness to change, we employed 3 strategies: correlation of change between visits, association of raw T score change between visits, and path-analysis models of change across visits, with T scores and path analysis models using physician reported change in childhood-onset SLE (GRC-MD1) and overall health status (GRC-MD2) as an external standard. For these analyses we condensed the GRC-MD1 and GRC-MD2 response options from 5 (much worse, somewhat worse, unchanged, somewhat better, and much better) to 3 (better, same, and worse).

For the correlation of change between visits, we correlated changes of the legacy HRQoL measure scores with changes in PROMIS-SF scores between visits and over time, using a mixed-effect model that adjusted for differences in patient demographics (age, sex, and race) and within-person correlation, using a random-effect model. This model provides information about the relationship of the responsiveness of legacy PROs to that of PROMIS-SFs.

For the association of raw T score change, we estimated changes in PROMIS-SF scores (T score) over time for patients who were considered better, same, or worse (GRC-MD1, GRC-MD2), using a similar mixed model as detailed above. Lastly, for the path-analysis models of change (11,12) (Figure 1), we evaluated the extent to which a given PROMIS-SF score at visit 1, 2, or 3 predicted a change (better or worse) in GRC-MD1 and GRC-MD2 ratings at visits 2 and 3. Path analysis is a special case of structural equation modeling, in which a single variable is used to measure each construct in the model (as opposed to multiple indicators per construct). Path analysis is a statistical technique that simultaneously solves a set of regression equations evaluating the hypothesized relationships among a set of variables. Figure 1 shows a path model that examines whether a PROMIS-SF score at a given visit (e.g., visit 2) predicts change in childhood-onset SLE (GRC-MD1) or overall health (GRC-MD2) status from the previous visit to the given visit (change from

Table 2. Bivariate correlation (r_{pool}) between pediatric PROMIS short forms and legacy measure subscales*

Legacy measures	Anger	Anxiety	Depressive symptoms	Fatigue	Mobility	Upper extremity	Pain	Peer relationships
SLEDAI-2K	0.12	0.06	0.03	0.11	−0.23	−0.12	0.16	0.11
BILAG†	0.01	0.07	−0.03	0.08	−0.26	−0.13	0.21	0.11
MD-global‡	0.10	0.09	0.07	0.08	−0.16	−0.02	0.12	0.08
SDI§	−0.07	−0.06	−0.07	−0.01	−0.11	−0.14	−0.00	−0.05
Functional Disability Inventory	0.37¶	0.48¶	0.42¶	0.62¶	−0.70¶	−0.55¶	0.62¶	−0.19
PedsQL-GC								
Summary score	−0.57¶	−0.68¶	−0.64¶	−0.78¶	0.69¶	0.49¶	−0.74¶	0.30¶
Physical function	−0.44¶	−0.53¶	−0.48¶	−0.70¶	0.72¶	0.50¶	−0.68¶	0.16
Emotional function	−0.63¶	−0.73¶	−0.72¶	−0.67¶	0.51¶	0.38¶	−0.61¶	0.25
Social function	−0.46¶	−0.50¶	−0.49¶	−0.54¶	0.49¶	0.38¶	−0.54¶	0.44¶
School function	−0.45¶	−0.58¶	−0.53¶	−0.71¶	0.52¶	0.33¶	−0.66¶	0.26
PedsQL-RM								
Summary score	−0.52¶	−0.66¶	−0.62¶	−0.74¶	0.62¶	0.51¶	−0.72¶	0.25
Pain and hurt	−0.44¶	−0.52¶	−0.47¶	−0.72¶	0.68¶	0.44¶	−0.72¶	0.12
Daily activity	−0.34¶	−0.43¶	−0.41¶	−0.53¶	0.56¶	0.61¶	−0.54¶	0.19
Treatment	−0.47¶	−0.54¶	−0.56¶	−0.51¶	0.43¶	0.39¶	−0.51¶	0.24
Worry	−0.35¶	−0.52¶	−0.43¶	−0.53¶	0.36¶	0.25	−0.52¶	0.09
Communication	−0.35¶	−0.50¶	−0.45¶	−0.49¶	0.32¶	0.24	−0.44¶	0.30
SMILEY								
Summary score	0.26	0.26	0.25	0.28	−0.22	−0.14	0.29	0.02
Effect on self	0.33¶	0.34¶	0.34¶	0.39¶	−0.30	−0.18	0.39¶	−0.09
Limitations	0.10	0.07	0.06	0.03	−0.05	−0.03	0.03	0.12
Social	−0.46¶	−0.50¶	−0.49¶	−0.54¶	0.49¶	0.38¶	−0.54¶	0.44¶
Burden of childhood-onset SLE	0.30	0.33¶	0.28	0.36¶	−0.31¶	−0.20	0.38¶	−0.08
C-HAQ								
Summary score	0.24	0.28	0.28	0.42¶	−0.62¶	−0.74¶	0.45¶	−0.11
Dressing/grooming	0.23	0.31¶	0.28	0.42¶	−0.58¶	−0.66¶	0.41¶	−0.10
Arising	0.24	0.28	0.27	0.46¶	−0.68¶	−0.54¶	0.51¶	−0.16
Eating	0.18	0.25	0.22	0.38¶	−0.55¶	−0.74¶	0.40¶	−0.11
Walking	0.23	0.29	0.24	0.36¶	−0.61¶	−0.55¶	0.42¶	−0.09
Hygiene	0.27	0.26	0.31¶	0.43¶	−0.61¶	−0.67¶	0.45¶	−0.12
Reach	0.26	0.28	0.29	0.46¶	−0.58¶	−0.65¶	0.50¶	−0.10
Play	0.32¶	0.37¶	0.34¶	0.53¶	−0.68¶	−0.60¶	0.59¶	−0.14
Grip	0.28	0.33¶	0.31¶	0.44¶	−0.54¶	−0.69¶	0.49¶	−0.18
CHQ-PF50								
Psychosocial summary score	−0.37¶	−0.32¶	−0.34¶	−0.36¶	0.40¶	0.21	−0.36¶	0.32¶
Physical summary score	−0.16	−0.26	−0.21	−0.37¶	0.52¶	0.37¶	−0.41¶	0.03
Physical functioning	−0.17	−0.26	−0.22	−0.35¶	0.57¶	0.33¶	−0.35¶	0.06
Bodily pain	−0.21	−0.29	−0.25	−0.41¶	0.52¶	0.33¶	−0.43¶	0.08
General health perception	−0.11	−0.27	−0.18	−0.25	0.28	0.21	−0.30	0.02
Role/social-physical	−0.24	−0.20	−0.27	−0.28	0.34¶	0.32¶	−0.33¶	0.18
Role/social-emotional/behavioral	−0.16	−0.25	−0.25	−0.35¶	0.49¶	0.35¶	−0.37¶	0.17
Self-esteem	−0.32¶	−0.32¶	−0.35¶	−0.35¶	0.48¶	0.19	−0.28	0.32¶
Mental health	−0.45¶	−0.37¶	−0.40¶	−0.37¶	0.37¶	0.20	−0.38¶	0.21
Behavior	−0.34¶	−0.19	−0.23	−0.25	0.14	0.06	−0.23	0.31¶
Mental health	−0.45¶	−0.37¶	−0.40¶	−0.37¶	0.37¶	0.20	−0.38¶	0.21

* Values are the pooled correlation coefficients (r_{pool}) across visits (n = 280 patient visits). PROMIS = Patient-Reported Outcomes Measurement Information System; SLEDAI-2K = Systemic Lupus Erythematosus Disease Activity Index 2000; BILAG = British Isles Lupus Assessment Group index; MD-global = physician global disease assessment; SDI = Systemic Lupus International Collaborating Clinics/American College of Rheumatology Damage Index; PedsQL-GC = Pediatric Quality of Life Generic Core Scale 4.0; PedsQL-RM = Pediatric Quality of Life Rheumatology Module 3.0; SMILEY = Simple Measure of Impact of Lupus Erythematosus in Youngsters; C-HAQ = Childhood Health Assessment Questionnaire; CHQ-PF50 = Child Health Questionnaire with 50 questions.
† Scoring: A = 12, B = 8, C = 1, D = 0, E = 0.
‡ On a 10-point Likert scale, where 0 = inactive disease.
§ Range 0–47, where 0 = absence of damage.
¶ $P < 0.001$ and $r > 0.30$.

visit 1 to visit 2), and the extent to which the visit 1 PROMIS score predicts the visit 2 and 3 PROMIS scores. Using Mplus software (34), we fit a path model for each PROMIS-SF across 2 different physician-reported change variables (GRC-MD1, GRC-MD2). The path models produced a standardized coefficient (β) of how many SDs the dependent variable (y axis: GRC-MD1, GRC-MD2 at visits 2 and 3) changes given a SD increase in predictor variable (x axis: PROMIS-SFs at visits 1,

Table 3. Pediatric PROMIS short form domain score change across visits and relationship to change in childhood-onset SLE, health status, and disease activity*

Variable/category	Anger	Anxiety	Depressive symptoms	Fatigue	Mobility	Upper extremity function	Pain interference	Peer relationships
Change in childhood-onset SLE†								
Better	−3.2 ± 1.4‡	−2.7 ± 1.3‡	−1.3 ± 1.4	−2.6 ± 1.6	2.9 ± 1.2‡	2.8 ± 1.5	−3.2 ± 1.3‡	−0.0 ± 1.5
Same	−0.5 ± 1.3	1.0 ± 1.1	1.7 ± 1.2	0.3 ± 1.4	0.5 ± 1.1	0.1 ± 1.3	−0.1 ± 1.2	−0.3 ± 1.4
Worse	0.4 ± 2.0	1.1 ± 1.8	2.0 ± 1.9	−0.2 ± 2.1	−4.0 ± 1.7‡	−1.4 ± 2.0	1.3 ± 1.8	−0.9 ± 2.1
Change in health§								
Better	−3.3 ± 1.4‡	−3.1 ± 1.3‡	−1.4 ± 1.4	−2.5 ± 1.5	3.1 ± 1.2‡	2.4 ± 1.5	−3.3 ± 1.3‡	−0.6 ± 1.5
Same	−0.3 ± 1.3	1.3 ± 1.2	2.1 ± 1.2	0.6 ± 1.4	−0.5 ± 1.1	−0.4 ± 1.3	0.2 ± 1.2	0.1 ± 1.4
Worse	0.4 ± 1.9	1.2 ± 1.7	1.6 ± 1.8	−0.9 ± 2.0	−1.7 ± 1.6	0.1 ± 1.9	0.9 ± 1.7	−0.9 ± 2.0
Change in MD-global (MD-VAS)								
Better	−5.2 ± 1.9‡	−1.7 ± 1.7	−1.6 ± 1.7	−1.2 ± 2.1	2.4 ± 1.6	2.2 ± 1.5	−2.5 ± 1.9	−1.9 ± 2.1
Same	−0.5 ± 1.0	0.6 ± 0.9	0.8 ± 0.9	−0.4 ± 1.1	−0.1 ± 0.9	−0.4 ± 0.8	0.4 ± 1.0	−0.5 ± 1.1
Worse	−0.9 ± 2.5	1.9 ± 2.2	5.0 ± 2.3‡	−1.4 ± 2.7	−0.8 ± 2.1	2.9 ± 1.8	−1.2 ± 2.4	3.1 ± 2.6
Change in SLEDAI-2K								
Better	−4.1 ± 1.8‡	−0.7 ± 1.6	−0.8 ± 1.7	−1.7 ± 2.0	4.2 ± 1.5‡	1.8 ± 1.4	−2.2 ± 1.8	−2.0 ± 2.0
Same	−0.6 ± 1.1	0.9 ± 0.9	1.7 ± 1.0	−0.2 ± 1.2	−0.8 ± 0.9	−0.2 ± 0.8	0.6 ± 1.0	−0.3 ± 1.1
Worse	−1.6 ± 2.1	−1.1 ± 1.8	−0.3 ± 1.9	−0.3 ± 2.3	−1.7 ± 1.8	0.8 ± 1.6	−1.1 ± 2.1	0.2 ± 2.3
Change in BILAG								
Better	−2.2 ± 1.5	−1.0 ± 1.3	1.3 ± 1.4	0.7 ± 1.7	3.1 ± 1.3‡	3.1 ± 1.1‡	−3.3 ± 1.5‡	−2.2 ± 1.6
Same	−1.2 ± 1.2	1.2 ± 1.1	1.0 ± 1.1	0.0 ± 1.3	−1.0 ± 1.0	−1.0 ± 0.9	1.0 ± 1.2	−0.6 ± 1.3
Worse	−1.2 ± 1.8	−0.2 ± 1.6	−0.1 ± 1.6	−3.2 ± 1.9	−1.7 ± 1.5	−0.4 ± 1.3	1.4 ± 1.7	1.7 ± 1.9

* Values are the T score means ± SE across visits (pooled data). PROMIS = Patient-Reported Outcomes Measurement Information System; SLE = systemic lupus erythematosus; MD-global = physician global disease assessment; VAS = visual analog scale; SLEDAI-2K = Systemic Lupus Erythematosus Disease Activity Index 2000; BILAG = British Isles Lupus Assessment Group index.
† GRC-MD1: visit 2: better 52 (54%), same 33 (34%), worse 11 (11%); visit 3: better 32 (38%), same 38 (45%), worse 14 (17%).
‡ $P < 0.05$.
§ GRC-MD2: visit 2: better 56 (58%), same 25 (26%), worse 15 (16%); visit 3: better 36 (43%), same 34 (40%), worse 14 (17%).

2, and 3). The β can be interpreted similarly to a correlation coefficient (r). All statistical analyses were completed with Stata 13 and Mplus software, version 7.1.

RESULTS

Demographics and PROs. A total of 100 patients were enrolled (demographics and disease features at baseline are summarized in Table 1), representing all patients within the target age stratum fulfilling eligibility criteria at each site. Six patients declined study participation. Of the 100 patients who completed visit 1, 96 completed visit 2, and 84 completed visit 3. Patients not completing all study visits did not significantly differ in demographics or disease features from patients who remained in the study. The same held true for the 6 patients declining study participation.

As summarized in Table 1, the cohort (n = 100) was 80% female with a mean ± SD age of 15.8 ± 22 years. For the racial profile, 33% self-identified as white, 48% as African American, and 11% as other, with 8% reporting Hispanic ethnicity. At visit 1, there were 16% and 14% of patients who had SLEDAI-2K and BILAG scores of 0, respectively, and 73% had no damage (SDI = 0). PRO responses for all HRQoL measures at baseline (visit 1) are also shown in Table 1.

Feasibility. For all completed visits, 100% of the patients successfully completed the PROMIS-SFs. Electronic completion through the assessment center of all 8 PROMIS-SFs averaged less than 5 minutes, with an individual item average of 5 seconds. Time to complete the individual PROMIS-SF domains averaged 37 seconds (range 28–48). $PROMIS_{Fatigue}$ completion took the longest (48 seconds), and the $PROMIS_{PF\text{-}UExt}$ the least amount of time (28 seconds) to complete. None of the patients reported difficulty understanding the items according to the informal debriefing after completion of the PROMIS-SFs.

Reliability. Cronbach's alpha for all PROMIS-SFs ranged 0.88–0.96 for visit 1 and exceeded 0.91 for visits 2 and 3. Cronbach's alpha for all PROMIS-SFs pooled data across all visits ranged 0.91–0.97. Details are provided online in Supplementary Table 1 (available on the *Arthritis Care & Research* web site at http://onlinelibrary.wiley.com/doi/10.1002/acr.22927/abstract).

Construct validity. As summarized in Table 2, the PROMIS-SF scores were moderately to highly correlated ($r_{pool} > 0.5$) with the summary scores of the HRQoL legacy measures (PedsQL-GC, PedsQL-RM, CHQ-psychosocial summary, CHQ-physical summary, C-HAQ, and FDI). The highest correlations were observed for the PedsQL-GC and PedsQL-RM scores and the lowest with the SMILEY. The

Table 4. Path analysis of the pediatric PROMIS short forms and prediction of change in childhood-onset SLE and health over time*

Variable category	Anger	Anxiety	Depressive symptoms	Fatigue	Mobility	Upper extremity	Pain interference	Peer relationships
Change in childhood-onset SLE (GRC-MD1)								
Between visits 1 & 2								
Better	−0.7 ± 0.3†	−0.3 ± 0.2	−0.4 ± 0.3	−0.7 ± 0.3†	0.4 ± 0.2	0.7 ± 0.3†	−0.6 ± 0.3†	−0.2 ± 0.3
Worse	−0.2 ± 0.4	−0.2 ± 0.4	0.0 ± 0.3	−0.3 ± 0.5	0.3 ± 0.3	0.6 ± 0.3	−0.3 ± 0.3	0.4 ± 0.4
Between visits 2 & 3								
Better	0.1 ± 0.2	−0.1 ± 0.1	0.0 ± 0.2	0.0 ± 0.2	0.3 ± 0.1	0.1 ± 0.1	−0.1 ± 0.1	0.1 ± 0.2
Worse	0.2 ± 0.2	0.1 ± 0.2	0.1 ± 0.2	0.0 ± 0.2	−0.4 ± 0.1†	−0.2 ± 0.1	0.3 ± 0.2	−0.1 ± 0.2
Change in health (GRC-MD2)								
Between visits 1 & 2								
Better	−0.6 ± 0.3†	−0.3 ± 0.2	−0.4 ± 0.3	−0.7 ± 0.3†	0.3 ± 0.2	0.6 ± 0.3†	−0.6 ± 0.3†	−0.1 ± 0.3
Worse	−0.0 ± 0.3	−0.2 ± 0.3	0.1 ± 0.3	−0.0 ± 0.4	−0.1 ± 0.3	0.2 ± 0.3	−0.2 ± 0.3	0.2 ± 0.4
Between visits 2 & 3								
Better	0.0 ± 0.1	−0.0 ± 0.1	0.0 ± 0.2	0.0 ± 0.1	0.2 ± 0.1	0.2 ± 0.1	−0.1 ± 0.1	0.1 ± 0.2
Worse	0.1 ± 0.2	0.1 ± 0.1	0.1 ± 0.2	0.1 ± 0.1	−0.6 ± 0.1†	−0.2 ± 0.1	0.3 ± 0.2	0.1 ± 0.2

* Values are the standardized coefficients ± SE. PROMIS = Patient-Reported Outcomes Measurement Information System; SLE = systemic lupus erythematosus; GRC-MD1 = global rating scale of change, physician rated change in childhood-onset SLE severity; GRC-MD2 = global rating scale of change, physician rated change in overall health status.
† $P < 0.05$.

psychosocial PROMIS-SFs ($PROMIS_{Anger}$, $PROMIS_{Anxiety}$, $PROMIS_{Depression}$, $PROMIS_{PeerRel}$) correlated highly with the CHQ-psychosocial summary and FDI, while the physical function PROMIS-SF domains ($PROMIS_{PF\text{-}Mobility}$, $PROMIS_{PF\text{-}UExt}$, $PROMIS_{Fatigue}$, $PROMIS_{Pain}$) correlated highly with CHQ-physical summary, C-HAQ, and FDI. Further summarized in Table 2, legacy subscale correlations are similar to legacy summary score correlations with the PROMIS-SFs.

The SMILEY summary score correlated only weakly at best with the PROMIS-SFs, but a few of the SMILEY subscales had mild to moderate correlation with the PROMIS-SFs. In addition, PROMIS-SF scores were no more than weakly correlated ($r_{pool} < 0.26$) with measures of disease activity (SLEDAI-2K, BILAG, or MD-global) or damage (SDI).

Responsiveness to change. Based on GRC-MD1 and GRC-MD2, 33 patients (34%) and 25 patients (26%) remained stable (unchanged) between visits 1 and 2, and 38 patients (45%) and 34 patients (40%) between visits 2 and 3, respectively. Also based on GRC-MD1 and GRC-MD2, between visits 1 and 2, 52 patients (54%) and 56 patients (58%) were considered improved (somewhat or much better), and between visits 2 and 3, 32 patients (38%) and 36 patients (43%), respectively. Few patients worsened between study visits (GRC-MD1/GRC-MD2 rated as somewhat worse or much worse; between visits 1 and 2, 11 and 15 patients, and between visits 2 and 3, 14 and 14 patients, respectively).

For the first strategy for measuring responsiveness to change, the correlation of change between visits, correlation analysis of PRO change scores for patients who improved or worsened between visits showed mostly low-to-fair correlation ($r_{pool} \leq 0.42$, $P < 0.001$) of change of the legacy measure summary scores (FDI, C-HAQ, CHQ-psychosocial summary, CHQ-physical summary, PedsQL-GC, PedsQL-RM, and SMILEY) with the change of the scores of the PROMIS-SFs (see Supplementary Table 2, available on the *Arthritis Care & Research* web site at http://onlinelibrary.wiley.com/doi/10.1002/acr.22927/abstract).

The second strategy, correlation of raw T scores between visits, which evaluated changes of the PROMIS-SF scores with changes of childhood-onset SLE and overall health as rated by the physician (GRC-MD1, GRC-MD2), using mixed repeated-measure models, showed appropriate parallel changes in scores of PROMIS-SFs with physician-rated change (Table 3). Significant improvement ($P < 0.05$) in $PROMIS_{Anger}$, $PROMIS_{Anxiety}$, $PROMIS_{PF\text{-}Mobility}$, and $PROMIS_{Pain}$ was observed, with improvement in childhood-onset SLE and overall health, while worsening childhood-onset SLE was associated with significant ($P < 0.05$) decrease in $PROMIS_{PF\text{-}Mobility}$ score. Also, PROMIS-SF scores remained stable in the setting of stable (unchanged/same) childhood-onset SLE and overall health status. Further, childhood-onset SLE disease activity improvement was accompanied by significant ($P < 0.05$) improvement in scores for $PROMIS_{Anger}$ (SLEDAI-2K, MD-global), $PROMIS_{PF\text{-}Mobility}$ (SLEDAI-2K, BILAG), $PROMIS_{PF\text{-}UExt}$, and $PROMIS_{Pain}$ (BILAG only). Further, MD-global worsening was associated with a statistically significant ($P < 0.05$) increase in $PROMIS_{Depression}$ score.

The results of the path analysis models of the PROMIS-SFs predicting change in childhood-onset SLE and overall health (GRC-MD1, GRC-MD2) demonstrated appropriate prediction change in childhood-onset SLE and overall health (Table 4). Statistically significant change ($P < 0.05$) was predicted in the setting of childhood-onset SLE improvement when $PROMIS_{Anger}$, $PROMIS_{Fatigue}$, $PROMIS_{Pain}$, and $PROMIS_{PF\text{-}UExt}$ improved and predicted childhood-onset SLE worsening when $PROMIS_{PF\text{-}Mobility}$ worsened. Similar results were observed for change in overall health. We did not observe statistically significant relationships for $PROMIS_{Anxiety}$, $PROMIS_{Depression}$, or $PROMIS_{PeerRel}$, but expected patterns were present.

DISCUSSION

The objectives of this study were to investigate the feasibility, internal consistency, construct validity, and responsiveness to change of the PROMIS-SFs in a pediatric population with childhood-onset SLE in a clinical setting. Our study focused on 8 distinct PROMIS-SFs: anger, anxiety, depressive symptoms, fatigue, physical function-mobility, physical function-upper extremity, pain interference, and peer relationships, i.e., health domains that seemed most relevant to childhood-onset SLE, among the PROMIS-SFs available for pediatric populations at the time of the study. Our findings show that PROMIS-SFs offer a valid option to efficiently collect PROs in childhood-onset SLE in a clinical setting, given outstanding feasibility and minimal time burden.

Construct validity of the PROMIS-SFs was demonstrated with high correlation with similar constructs (e.g., $PROMIS_{PF\text{-}Mobility}$ and C-HAQ, FDI, and fatigue) and low correlation with dissimilar constructs (e.g., $PROMIS_{PeerRel}$ and SLEDAI-2K, pain, and SDI). This correlation held true when PROMIS-SFs were compared with the legacy subscales as well (e.g., high correlation: $PROMIS_{PF\text{-}Mobility}$ and C-HAQ for arising; $PROMIS_{Pain}$ and PedsQL-RM for pain and hurt; and low correlation: $PROMIS_{PeerRel}$ and PedsQL-GC for physical function; $PROMIS_{Anxiety}$ and C-HAQ for eating). As expected, the physical domains moved together and the psychosocial domains trended together.

Responsiveness of the PROMIS-SFs was demonstrated by 3 complementary strategies, all supporting sensitivity to change. The different approaches provide strong support for the usefulness of the PROMIS-SFs to capture clinically relevant changes in HRQoL in patients with childhood-onset SLE. As there was relatively low disease activity at baseline and only a few patients experienced a significant childhood-onset SLE flare during the study, as rated by the GRC-MD1 scale, statistical significance was not consistently reached when the PROMIS-SF scores were used as predictors of change in childhood-onset SLE.

In all of the analyses that used the GRC-MD scales for assessing responsiveness of the PROMIS-SFs, physician ratings rather than patient ratings served as external standards. Based on the known weakness of physicians to gauge patient HRQoL, lower estimates of responsiveness might have been expected. Arguably, the strongest support for the responsiveness of the PROMIS-SFs is provided in our analyses of the association of raw T score change between visits, showing moderate associations with the score changes of patient-completed legacy HRQoL measures.

On the other hand, physicians' rating of improvement in childhood-onset SLE and overall health tracked well with improved disease control (SLEDAI-2K, BILAG, and MD-global) and was associated with important changes in physical function, anger, anxiety, depression, and pain as measured by the PROMIS-SFs. There was also high correlation of fatigue with FDI scores, and as expected, the $PROMIS_{Fatigue}$ score underlines the relevance of addressing patients' reports of fatigue in the medical management of childhood-onset SLE. Together, these results stress the profound impact of childhood-onset SLE on many aspects of physical health and HRQoL.

Another objective of PROMIS is to develop meaningful, precise instruments while reducing respondent burden (35). In this study the entire battery of PROMIS-SFs was completed in approximately 5 minutes, which equates to less than 1 minute per domain. Our experience is in line with observations made in previous studies (36,37). This timing supports a decreased respondent burden when compared with legacy measures that require 5 to 15 minutes each for completion (38–40).

PROMIS offers flexibility and customization, as PROMIS-SFs can be selected, collected and maintained electronically through an assessment center. While the electronic features of the assessment center can improve data management and improve feasibility, we encountered difficulties with assessmentcenter.net, resulting in loss of data or replicated data. Such shortcomings can probably be addressed quite easily by minimal programming changes or instructions for the use of the software.

Offering a comparison of PROs across disease groups is another aim of PROMIS (35), and as the PROMIS-SFs are validated for different disease groups, comparison across the disease groups can be achieved. In this study we validated the PROMIS-SF for use in childhood-onset SLE, giving providers another tool to use to measure HRQoL in childhood-onset SLE, but also allowing for comparison of HRQoL between childhood-onset SLE and other chronic diseases to enhance understanding of HRQoL in different chronic conditions.

There are several limitations to our study. During the study period, only English versions of the PROMIS-SFs were available, and as a result only English-speaking participants were enrolled in this study. The PROMIS-SFs are now available in Spanish and Dutch, with $PROMIS_{Anger}$, $PROMIS_{Fatigue}$, $PROMIS_{Pain}$, $PROMIS_{PeerRel}$, $PROMIS_{PF\text{-}Mobility}$, and $PROMIS_{PF\text{-}UExt}$ translation efforts underway for simplified Chinese, Portuguese, German, and Swedish. Also, as expected for childhood-onset SLE, the majority of patients were teenagers. Thus findings and experiences with the electronic data capture may be different in younger children with childhood-onset SLE. Nonetheless, our study included children as young as age 10 years. As in many studies in pediatric rheumatology, sample size was limited and likely contributed to difficulty demonstrating responsiveness to change for all of the PROMIS-SFs included in the study. This difficulty is especially true as it pertains to worsening of childhood-onset SLE and overall health. However, use of 3 complementary strategies to support sensitivity to change are reported, all suggesting that PROMIS-SFs are suitable to capture clinically relevant change in HRQoL in childhood-onset SLE. As this study took place at 2 centers, a center bias cannot be excluded, and next steps would include expanding this study to other centers. There was an excellent retention rate throughout the study, with few missing data values for the cohort, and patients studied were well phenotyped and representative of the childhood-onset SLE populations followed at the 2 tertiary pediatric centers, adding to the validity of analyses presented.

In conclusion, this study shows preliminary evidence of validation of the PROMIS-SFs for use as HRQoL measurement in childhood-onset SLE. The PROMIS-SFs are a

reliable, responsive, and efficient choice for PRO measurement in childhood-onset SLE, taking advantage of easy interpretation of scores and change in scores, thereby reducing respondent burden and making HRQoL assessment feasible in research and clinical care settings as well as across disease groups.

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All authors were involved in drafting the article or revising it critically for important intellectual content, and all authors approved the final version to be submitted for publication. Dr. Brunner had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.
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REFERENCES

1. Brunner HI, Higgins GC, Wiers K, Lapidus SK, Olson JC, Onel K, et al. Health-related quality of life and its relationship to patient disease course in childhood-onset systemic lupus erythematosus. J Rheumatol 2009;36:1536–45.
2. Ruperto N, Buratti S, Duarte-Salazar C, Pistorio A, Reiff A, Bernstein B, et al. Health-related quality of life in juvenile-onset systemic lupus erythematosus and its relationship to disease activity and damage. Arthritis Rheum 2004;51:458–64.
3. Thumboo J, Strand V. Health-related quality of life in patients with systemic lupus erythematosus: an update. Ann Acad Med Singapore 2007;36:115–22.
4. Jones JT, Cunningham N, Kashikar-Zuck S, Brunner HI. Pain, fatigue, and psychological impact on health-related quality of life in childhood-onset lupus. Arthritis Care Res (Hoboken) 2016;68:73–80.
5. Schmeding A, Schneider M. Fatigue, health-related quality of life and other patient-reported outcomes in systemic lupus erythematosus. Best Pract Res Clin Rheumatol 2013;27:363–75.
6. Eiser C, Jenney M. Measuring quality of life. Arch Dis Child 2007;92:348–50.
7. Varni JW, Burwinkle TM, Lane MM. Health-related quality of life measurement in pediatric clinical practice: an appraisal and precept for future research and application. Health Qual Life Outcomes 2005;3:34.
8. Ware JE Jr. The Patient-Reported Outcomes Measurement Information System (PROMIS) seeks to improve and standardize measures of five generic health-related QOL domains. Patient Reported Outcomes Newsletter 2007;38. URL: http://www.pro-newsletter.com/content/view/184/53/.
9. Silva CA, Avcin T, Brunner HI. Taxonomy for systemic lupus erythematosus with onset before adulthood. Arthritis Care Res (Hoboken) 2012;64:1787–93.
10. Domain frameworks PROMIS adult self-reported health. 2015. URL: http://www.nihpromis.org/measures/domainframework1.
11. Reeve BB, Hays RD, Bjorner JB, Cook KF, Crane PK, Teresi JA, et al. Psychometric evaluation and calibration of health-related quality of life item banks: plans for the Patient-Reported Outcomes Measurement Information System (PROMIS). Med Care 2007;45(Suppl 1):S22–31.
12. PROMIS scoring manuals. 2015. URL: www.assessmentcenter.net/Manuals.aspx.
13. DeWitt EM, Stucky BD, Thissen D, Irwin DE, Langer M, Varni JW, et al. Construction of the eight-item patient-reported outcomes measurement information system pediatric physical function scales: built using item response theory. J Clin Epidemiol 2011;64:794–804.
14. Varni JW, Stucky BD, Thissen D, Dewitt EM, Irwin DE, Lai JS, et al. PROMIS Pediatric Pain Interference Scale: an item response theory analysis of the pediatric pain item bank. J Pain 2010;11:1109–19.
15. Irwin DE, Stucky B, Langer MM, Thissen D, Dewitt EM, Lai JS, et al. An item response analysis of the pediatric PROMIS anxiety and depressive symptoms scales. Qual Life Res 2010;19:595–607.
16. Irwin DE, Stucky BD, Langer MM, Thissen D, DeWitt EM, Lai JS, et al. PROMIS Pediatric Anger Scale: an item response theory analysis. Qual Life Res 2012;21:697–706.
17. Kashikar-Zuck S, Flowers SR, Claar RL, Guite JW, Logan DE, Lynch-Jordan AM, et al. Clinical utility and validity of the Functional Disability Inventory among a multicenter sample of youth with chronic pain. Pain 2011;152:1600–7.
18. Claar RL, Walker LS. Functional assessment of pediatric pain patients: psychometric properties of the functional disability inventory. Pain 2006;121:77–84.
19. Moorthy LN, Peterson MG, Baratelli M, Harrison MJ, Onel KB, Chalom EC, et al. Multicenter validation of a new quality of life measure in pediatric lupus. Arthritis Rheum 2007;57:1165–73.
20. Meiorin S, Pistorio A, Ravelli A, Iusan SM, Filocamo G, Trail L, et al. Validation of the Childhood Health Assessment Questionnaire in active juvenile systemic lupus erythematosus. Arthritis Rheum 2008;59:1112–9.
21. Singh G, Athreya BH, Fries JF, Goldsmith DP. Measurement of health status in children with juvenile rheumatoid arthritis. Arthritis Rheum 1994;37:1761–9.
22. Landgraf JM, Abetz LN, Ware JE. The Childhood Health Questionnaire user's manual. 2nd ed. Boston (MA): HealthAct; 1999.
23. Asmussen L, Olson LM, Grant EN, Landgraf JM, Fagan J, Weiss KB. Use of the child health questionnaire in a sample of moderate and low-income inner-city children with asthma. Am J Respir Crit Care Med 2000;162(Pt 1):1215–21.
24. Gladman D, Ginzler E, Goldsmith C, Fortin P, Liang M, Urowitz M, et al. The development and initial validation of the Systemic Lupus International Collaborating Clinics/American College of Rheumatology Damage Index for systemic lupus erythematosus. Arthritis Rheum 1996;39:363–9.
25. Brunner HI, Silverman ED, To T, Bombardier C, Feldman BM. Risk factors for damage in childhood-onset systemic lupus erythematosus: cumulative disease activity and medication use predict disease damage. Arthritis Rheum 2002;46:436–44.
26. Brunner HI, Feldman BM, Bombardier C, Silverman ED. Sensitivity of the Systemic Lupus Erythematosus Disease Activity Index, British Isles Lupus Assessment Group Index, and Systemic Lupus Activity Measure in the evaluation of clinical change in childhood-onset systemic lupus erythematosus. Arthritis Rheum 1999;42:1354–60.
27. Yee CS, Cresswell L, Farewell V, Rahman A, Teh LS, Griffiths B, et al. Numerical scoring for the BILAG-2004 index. Rheumatology (Oxford) 2010;49:1665–9.
28. Isenberg DA, Rahman A, Allen E, Farewell V, Akil M, Bruce IN, et al. BILAG 2004: development and initial validation of an updated version of the British Isles Lupus Assessment Group's disease activity index for patients with systemic lupus erythematosus. Rheumatology (Oxford) 2005;44:902–6.
29. George DM, Mallery P. SPSS for Windows step by step: a simple guide and reference. 11.0 update. 4th ed. Boston: Allyn & Bacon; 2003.
30. Westen D, Rosenthal R. Quantifying construct validity: two simple measures. J Pers Soc Psychol 2003;84:608–18.
31. Classification and Response Criteria Subcommittee of the American College of Rheumatology Committee on Quality Measures. Development of classification and response criteria for rheumatic diseases. Arthritis Rheum 2006;55:348–52.

32. Roy A. Estimating correlation coefficient between two variables with repeated observations using mixed effects model. Biom J 2006;48:286–301.
33. Mukaka MM. Statistics corner: a guide to appropriate use of correlation coefficient in medical research. Malawi Med J 2012;24:69–71.
34. Muthen LK, Muthen BO. Mplus user's guide. 7th ed. Los Angeles: Muthén & Muthén; 1998–2012.
35. Cella D, Yount S, Rothrock N, Gershon R, Cook K, Reeve B, et al. The Patient-Reported Outcomes Measurement Information System (PROMIS): progress of an NIH Roadmap cooperative group during its first two years. Med Care 2007; 45(Suppl 1):S3–11.
36. Khanna D, Maranian P, Rothrock N, Cella D, Gershon R, Khanna PP, et al. Feasibility and construct validity of PROMIS and "legacy" instruments in an academic scleroderma clinic. Value Health 2012;15:128–34.
37. Senders A, Hanes D, Bourdette D, Whitham R, Shinto L. Reducing survey burden: feasibility and validity of PROMIS measures in multiple sclerosis. Mult Scler 2014;20:1102–11.
38. Varni JW, Seid M, Smith Knight T, Burwinkle T, Brown J, Szer IS. The PedsQL in pediatric rheumatology: reliability, validity, and responsiveness of the Pediatric Quality of Life Inventory Generic Core Scales and Rheumatology Module. Arthritis Rheum 2002;46:714–25.
39. Hullmann SE, Ryan JL, Ramsey RR, Chaney JM, Mullins LL. Measures of general pediatric quality of life: Child Health Questionnaire (CHQ), DISABKIDS Chronic Generic Measure (DCGM), KINDL-R, Pediatric Quality of Life Inventory (PedsQL) 4.0 Generic Core Scales, and Quality of My Life Questionnaire (QoML). Arthritis Care Res (Hoboken) 2011;63(Suppl 11):S420–30.
40. Hersh A. Measures of health-related quality of life in pediatric systemic lupus erythematosus: Childhood Health Assessment Questionnaire (C-HAQ), Child Health Questionnaire (CHQ), Pediatric Quality of Life Inventory Generic Core Module (PedsQL-GC), Pediatric Quality of Life Inventory Rheumatology Module (PedsQL-RM), and Simple Measure of Impact of Lupus Erythematosus in Youngsters (SMILEY). Arthritis Care Res (Hoboken) 2011;63(Suppl 11): S446–53.