The PedsQL™ as a pediatric patient-reported outcome: reliability and validity of the PedsQL™ Measurement Model in 25,000 children

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The PedsQL™ Measurement Model was designed as a modular approach to measuring pediatric health-related quality of life, and developed to integrate the relative merits of generic and disease-specific approaches. The PedsQL™ 4.0 Generic Core Scales have been translated into over 60 languages, with published data on over 25,000 children and adolescents in more than 75 peer-reviewed journals since 2001 for healthy children and numerous pediatric chronic health conditions. The PedsQL™ Disease and Condition-Specific Modules were designed to measure health-related quality-of-life dimensions specifically tailored for pediatric chronic health conditions, and include the PedsQL™ Asthma, Arthritis/Rheumatology, Cancer, Diabetes, Cardiac and Cerebral Palsy Modules, as well as the generic PedsQL™ Multidimensional Fatigue Scale, Pediatric Pain Questionnaire™, Family Impact Module and Healthcare Satisfaction Module. The PedsQL™ has demonstrated reliability, validity, sensitivity and responsiveness for child self report for ages 5–18 years and parent proxy report for ages 2–18 years. The PedsQL™ has been shown to be related to other key constructs in pediatric healthcare such as access to needed care, healthcare barriers and quality of primary care. Future advances in the PedsQL Measurement Model include web-based electronic administration (ePedsQL™), integration into the electronic medical record, further efficacy and effectiveness outcome trials, including PedsQL™ ResourceConnect℠ and PedsQL™ TIPS℠, the development of the generic PedsQL™ Infant Scales for ages birth to 24 months and disease and condition-specific modules for other pediatric chronic health conditions.

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Patient-report outcomes

Patient-reported outcomes (PROs) are self-report instruments that directly measure the patient's perceptions of the impact of disease and treatment as clinical trial end points. They include multi-item health-related quality-of-life (HRQOL) instruments, as well as single-item measures (e.g., pain and visual analog scale), daily diaries, treatment adherence and healthcare satisfaction [1,2]. Pediatric PROs must be sensitive to cognitive development and should include both child self report and parent proxy report to reflect their potentially unique perspectives. However, imperfect agreement between self and proxy report, termed cross-informant variance [3], has been consistently documented in the PRO measurement of children with chronic health conditions and healthy children [4]. The demonstration of cross-informant variance and the general acceptance that HRQOL derives from an individual's perceptions [5], indicate an essential need in pediatric HRQOL measurement for reliable and valid child self-report instruments for the broadest possible age range. With this in mind, the Pediatric

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Quality of Life Inventory™ (PedsQL™) was conceptualized as an age-appropriate HRQOL PRO for a wide age range of children [6,7].

PedsQL™ Measurement Model

The PedsQL Measurement Model was designed as a modular approach to measuring pediatric HRQOL, and was developed to integrate the relative merits of generic and disease-specific approaches [6]. There are definite advantages of utilizing both generic and disease-specific HRQOL instruments. The generic instrument enables comparisons to be made across pediatric populations and facilitates benchmarking with healthy populations, while the disease-specific instrument is tailored for a particular health condition and enhances measurement sensitivity for health domains relevant to that condition.

Although other pediatric HRQOL instruments exist, including generic measures and disease-specific measures [8,9], it has been an explicit goal of the PedsQL Measurement Model to develop and test brief measures for the broadest age group empirically feasible, specifically including child self-report for the youngest children possible [6]. This goal was originally articulated in empiric efforts in the 1980s to measure pain perception in pediatric patients through the development and testing of the Varni/Thompson Pediatric Pain Questionnaire™ for children as young as 5 years of age [10].

The PedsQL includes child self report for ages 5–18 years and parent proxy report for ages 2–18 years [7,11]. The items chosen for inclusion were initially derived from the measurement properties of the child self-report scales, while the parent proxy-report scales were constructed to directly parallel the child self-report items. Thus, the development and testing of the PedsQL as a pediatric PRO explicitly emphasizes the child's perceptions.

PedsQL™ 4.0 Generic Core Scales

Given that the PedsQL Measurement Model integrates generic core scales and disease-specific modules into one measurement system, the PedsQL 4.0 Generic Core Scales were specifically designed for application in both healthy and patient populations [7,11,12]. The PedsQL 4.0 Generic Core Scales have resulted from an extensive iterative process over the past 20 years. It has involved numerous patient and parent focus groups and individual focus interviews, item generation, cognitive interviewing, pretesting and subsequent field testing following standardized protocols [13–16], with international data on over 25,000 healthy children and children with numerous pediatric chronic health conditions published or in press in over 75 peer-reviewed journals since 2001 [7,11,12,17–43]. (A full listing of these publications with the details of the numerous pediatric chronic health conditions in which the instrument has been utilized is available at [101]).

The PedsQL 4.0 Generic Core Scales distinguish between healthy children and children with pediatric chronic health conditions. They have demonstrated sensitivity to disease severity and responsiveness through patient change over time, and show significant intercorrelations with disease-specific symptom scales (based on the conceptualization of disease-specific symptoms as causal indicators of generic HRQOL) [7,11,12,17–26,28–34,36–38,41–43,44]. Furthermore, the PedsQL 4.0 has shown an impact on clinical decision making, demonstrating significant associations with quality of healthcare, barriers to healthcare and prediction of healthcare costs over time [24,45–47]. The large and continuously expanding PedsQL 4.0 Generic Core Scales Database℠ provides the opportunity for comparisons across pediatric chronic health conditions and benchmarking with healthy populations.

Examples of the published data from the PedsQL 4.0 Generic Core Scales Database for healthy children and children with chronic health conditions, demonstrating internal consistency reliability and validity for children as young as 5–7 years of age are shown in TABLE 1. Both child self-report and parent proxy-report data are included, the latter may be necessary to estimate child HRQOL when the child is either unable or unwilling to complete the HRQOL measure. While self report is considered the standard for measuring perceived HRQOL, it is often parents' perceptions of their children's HRQOL that influence healthcare utilization [48–50]. Thus, the imperfect agreement observed between child self-report and parent proxy report supports the need to measure the perspectives of both the child and parent in evaluating pediatric HRQOL since these perspectives may be independently related to healthcare utilization and risk factors. Nevertheless, proxy reports should be conducted with the knowledge that proxy ratings of HRQOL may be insufficiently accurate, and that child self report and parent proxy report should be measured whenever possible in order to provide their potentially unique perspectives [51].

Thus, the PedsQL 4.0 Generic Core Scales have consistently demonstrated in over 25,000 children and their parents the feasibility, reliability, validity, sensitivity and responsiveness required for a PRO in pediatric clinical trials for child self-report ages 5–18 years and parent proxy report for ages 2–18 years.

Importance of child self report for ages 5–7 years: an empiric illustration

Although most HRQOL measures include child self report for ages 8 years and older, the PedsQL 4.0 is the only generic HRQOL instrument that the authors are aware of that also includes child self-report for ages 5–7 years. A recent clinical trial in pediatric cancer illustrates the importance of including the youngest children empirically feasible. The influence of hemoglobin (Hb) response to epoetin alfa on HRQOL in anemic children receiving myelosuppressive chemotherapy was determined in a national multisite randomized controlled clinical trial using the PedsQL 4.0 [42]. This double-blind, placebo-controlled study of children ages 5–18 years with cancer and anemia, showed that PedsQL™ 4.0 Total Scale scores significantly improved from baseline among Hb responders but not among Hb nonresponders. Of particular significance, the greatest

Table 1. PedsQL™ 4.0 Generic Core Scales: reliability coefficients by age group and validity by patient population.

Patient Population	PedsQL™ total scale score reliability				PedsQL™ total scale score validity
	2–4 years	5–7 years	8–12 years	13–18 years	
Child self report					
Asthma		0.88	0.91	0.90	a < h; sensitivity to disease severity, responsiveness to tx
Cancer		0.82	0.89	0.92	c < h; sensitivity to tx status, responsiveness to tx
Cardiac		0.74	0.91	0.89	ca < h; sensitivity to severity
Cerebral palsy		0.78	0.85	0.91	cp < h; sensitivity to severity
Diabetes (type 1)		0.74	0.90	0.89	d < h; correlated with HbA1c, tx adherence, tx barriers
Rheumatology		0.85	0.92	0.92	r < h; sensitive to known disease group differences, tx
Psychiatric referral		0.73	0.85	0.87	rf < nrf; correlated with measures of psychopathology
Healthy		0.86	0.91	0.91	Responsiveness to healthcare access
Parent proxy report					
Asthma	0.86	0.90	0.91	0.93	a < h, sensitivity to disease severity, responsiveness to tx
Cancer	0.89	0.93	0.92	0.94	c < h; sensitivity to tx status, responsiveness to tx
Cardiac	0.93	0.92	0.94	0.93	ca < h; sensitivity to severity
Cerebral palsy	0.91	0.92	0.88	0.89	cp < h; sensitivity to severity
Diabetes (Type 1)	0.89	0.90	0.90	0.88	d < h; correlated with HbA1c, tx adherence, tx barriers
Rheumatology	0.77	0.93	0.94	0.94	r < h; sensitive to known disease group differences, tx
Psychiatric referral		0.86	0.84	0.91	rf < nrf; correlated with measures of psychopathology
Healthy	0.90	0.91	0.92	0.92	Responsiveness to healthcare access

Note: All known-group differences for validity analyses significant at least $p < 0.05$; patients lower HRQOL than healthy children. Empty cells where data is not applicable or available.
A: Asthma; C: Cancer; Ca: Cardiac; Cp: Cerebral Palsy; D: Diabetes; H: Healthy; Nrf: Not referred for psychiatric problems; R: Rheumatology; Rf: Referred for psychiatric problems.

between-group difference in Hb response rate was observed in patient self report for those aged 5–7 years, with this age group exhibiting the only significant difference in HRQOL – favoring epoetin alfa. Specifically, mean patient-reported PedsQL Total Scale Scores at the final visit were significantly greater in the epoetin alfa group in comparison with the placebo group among patients 5–7 years of age (88 vs 78.1, respectively, $p = 0.043$). Also, mean parent-reported PedsQL was not significantly different between groups or for any of the age-specific subsets. Thus, it was only the child self-report for ages 5–7 years that demonstrated a significant difference, which was consistent with their anemia status, in that 92.3% of patients aged 5–7 years in the epoetin alfa group were Hb responders.

PedsQL short forms

Finally, in certain contexts in which resources are extremely limited or for other practical and methodologic reasons, an even briefer version of the generic instrument is available. The PedsQL 4.0 Generic Core Scales Short Form (PedsQL 4.0 Short Form 15) is comprised of 15 items from the original 23-version, and has demonstrated reliability, validity, sensitivity and responsiveness in a clinical investigation of pediatric asthma patients [25,52].

Scoring the PedsQL

The 23-item PedsQL 4.0 Generic Core Scales encompass:

- Physical functioning (eight items, e.g., 'It is hard for me to walk more than one block')

- Emotional functioning (five items, e.g., 'I feel sad or blue')
- Social functioning (five items, e.g., 'I have trouble getting along with other kids')
- School functioning (five items, e.g., 'It is hard to pay attention in class')

The PedsQL 4.0 Generic Core Scales are comprised of parallel child self report and parent proxy-report formats. Child self report includes ages 5–7, 8–12 and 13–18 years. Parent proxy report includes ages 2–4 (toddler), 5–7 (young child), 8–12 (child) and 13–18 years (adolescent), and assess the parent's perceptions of their child's HRQOL. The items for each of the forms are essentially identical, differing in developmentally appropriate language, or first or third person tense. The instructions ask how much of a problem each item has been during the past month. A five-point response scale is utilized across child self report for ages 8–18 years and parent proxy-report (0 = never a problem; 1 = almost never a problem; 2 = sometimes a problem; 3 = often a problem; 4 = almost always a problem). To further increase the ease of use for the young child self-report (ages 5–7 years), the response scale is reworded and simplified to a three-point scale (0 = not at all a problem; 2 = sometimes a problem; 4 = a lot of a problem), with each response choice anchored to a happy-to-sad faces scale. Parent proxy report also includes the toddler age range (ages 2–4 years), which does not include a self-report form given developmental limitations on self-report for children younger than 5 years of age [53,54]. Items are reverse scored and linearly transformed to a 0–100 scale (0 = 100, 1 = 75, 2 = 50, 3 = 25, 4 = 0), with higher scores indicating fewer symptoms or problems so that higher scores indicate better HRQOL. Individual Scale Scores are computed as the sum of the items divided by the number of items answered (this accounts for missing data). If more than 50% of the items in the scale are missing, the Scale Score is not computed [55]. In the numerous PedsQL studies published since 2001, items on the PedsQL had minimal missing responses, suggesting that children and parents are willing and able to provide good quality data regarding the child's HRQOL.

The PedsQL Measurement Model emphasizes the child's perceptions. The items chosen for inclusion were derived from the measurement properties of the child self-report scales, while the parent proxy-report scales were constructed to directly parallel the child self-report items. The items selected for the PedsQL 4.0 reflect those of universal concern across childhood age groups. Attempts were made to keep wording, and thus the content, as similar as possible across parallel forms, while being sensitive to developmental differences in cognitive ability. For instance, the only differences between child and adolescent self-report is the use of 'kids' for items in the Social Functioning Scale in the child self-report version and 'teens' for those items in the adolescent self-report version, and 'It is hard to keep up with my peers' for the adolescent self-report version rather than 'It is hard to keep up when I play with other kids' for the child self-report version. Additionally, parent proxy-report for the toddler age range (ages 2–4 years) includes only three age-appropriate items for the School Functioning Scale and developmentally appropriate wording for some items in the other scales (e.g., 'Participating in active play or exercise' rather than 'Participating in sport activity or exercise'; 'Bathing' rather than 'Taking a bath or shower by him or herself'; 'Worrying' rather than 'Worrying about what will happen to him or her'). This scale construct consistency facilitates the evaluation of differences in HRQOL across and between age groups, as well as the tracking of HRQOL longitudinally. The PedsQL 4.0 is the only empirically validated generic pediatric HRQOL measurement instrument that the authors are aware of to span ages 2–18 for parent proxy-report and ages 5–18 years for child self-report while maintaining item and scale construct consistency.

Clinically important difference

The minimal clinically important difference (MCID) for PedsQL 4.0 scale scores has been determined through calculating the Standard Error of Measurement (SEM) [56]. MCID has been defined as the smallest difference in a score of a domain of interest that patients perceive to be beneficial and that would mandate, in the absence of troublesome side effects and excessive costs, a change in the patient's management [57]. The SEM has been linked to the MCID, in which one SEM identified the MCID in responsiveness in a HRQOL measure [58]. Excellent agreement between the SEM and MCID has been shown [58]. A 4.4 change in the PedsQL 4.0 Total Scale Score for child self-report has been determined as a minimal clinically meaningful difference, while for parent proxy-report a 4.5 change was determined as a minimal clinically meaningful difference [11].

Cut point for at-risk status

Cut-off points for at-risk status for impaired HRQOL were explored by examining the PedsQL 4.0 scale scores for one standard deviation below the mean of the total population sample. Scores approximating one standard deviation below the mean were designated as indicating an at-risk status for impaired HRQOL relative to the population means [28]. One standard deviation below the population mean was determined as a meaningful cut-off point score for an at-risk status for poor HRQOL relative to the population sample [11]. For child self-report, the PedsQL 4.0 Total Scale Score cut-off point was 69.7 (parent proxy-report score of 65.4). In order to provide the context for these cut-off scores, it is useful to examine PedsQL 4.0 Total Scale Scores for children with physician-diagnosed chronic health conditions. For example, children with newly diagnosed cancer undergoing treatment self-report a PedsQL 4.0 Total Scale Score of 68.9 (parent proxy-report score of 67.0) [19]. Similarly, children with rheumatic conditions (e.g., juvenile rheumatoid arthritis) self-report a PedsQL 4.0 Total Scale Score of 72.1 (parent proxy report score of 71) [23]. Thus, scores approximating one standard deviation below the population sample mean represent PedsQL 4.0 Total Scale Scores similar to children with a severe chronic health condition.

International translations

There are now over 60 translations of the PedsQL 4.0 Generic Core Scales [101]. Many of these translations were conducted by the Mapi Research Institute in Lyon, France, with the remaining translations conducted by research teams in countries worldwide. The Mapi Research Institute's translations are official PedsQL translations [59], while the individual research teams' translations are considered preliminary national translations until further validated by the Mapi Research Institute's translation team.

PedsQL Disease & Condition-Specific Modules

The PedsQL Disease and Condition Specific Modules were designed to measure HRQOL dimensions specifically tailored for pediatric chronic health conditions, and currently include the PedsQL Asthma [20,25], Arthritis/Rheumatology [23], Cancer [19], Diabetes [18], Cardiac [17] and Cerebral Palsy Modules [43], as well as the generic PedsQL Multidimensional Fatigue Scale [19,22], Pediatric Pain Questionnaire™ [10], Family Impact Module [60] and the Healthcare Satisfaction Module [61,62]. The PedsQL Module Scales were developed through focus groups, cognitive interviews, pretesting and field testing measurement development protocols [13–16]. New PedsQL Disease and Condition Specific Modules currently in various phases of development and testing include the PedsQL End-Stage Renal Disease Module, Organ Transplantation Module and Neuromuscular Disease Module, with other modules in the planning and early development stages.

Each PedsQL Disease and Condition Specific Module was developed based on the authors' research and clinical experiences in pediatric chronic health conditions generically, close collaboration with the disease and condition specific clinical team, and an instrument development protocol that consists of a review of the extant literature, patient and parent focus groups and individual focus interviews, item generation, cognitive interviewing, pretesting and subsequent field testing of the new measurement instrument in the target population.

The PedsQL Disease and Condition Specific Modules are comprised of parallel child self-report and parent proxy-report formats, exactly like the PedsQL 4.0 Generic Core Scales. This exact matching format greatly facilitates the integration of the generic and disease-specific scales as originally envisioned in the PedsQL Measurement Model.

In contrast to the PedsQL 4.0 Generic Core Scales and the generic PedsQL Multidimensional Fatigue Scale, there is no overall summary or composite score for the Asthma, Arthritis/Rheumatology, Cancer, Diabetes, Cardiac and Cerebral Palsy Modules. Rather, each Module contains disease-specific scales that are scored individually, and utilized as required to achieve the goals and objectives of a particular study. For instance, in a randomized clinical trial testing a new pharmaceutical intervention for pediatric asthma, the 11-item PedsQL 3.0 Asthma Module Asthma Symptoms Scale would be integrated with the 23- or 15-item PedsQL 4.0 Generic Core Scales when the intent of the intervention is to improve asthma symptom control and overall generic HRQOL. In this hypothetical study, for example, it would not be required, nor advised, to include all of the other Asthma Module Scales, such as the Worry and Communication Scales, since these constructs were not the primary objective of the intervention. However, the Asthma Treatment Problems Scale might be indicated if barriers to medication adherence were of empiric interest. Thus, the primary outcome measures in this hypothetical randomized clinical trial would be the Asthma Symptoms Scale and the PedsQL 4.0 Generic Core Total Scale Score, with the individual Scale Scores from the generic core instrument as secondary outcomes.

This strategy of selecting individual Module Scales depending on the intent of the randomized clinical trial serves to reduce respondent burden and the costs of the trial, and may increase statistical efficiency by empirically determining the number of patients needed in a clinical trial through examining subscale intercorrelations, standard deviations and predicted relative effects [63]. Vickers has delineated a useful strategy for determining the statistical implications of selecting an individual subscale or a combination of subscales as the primary outcome in a randomized trial [63]. When subscales measure distinctly different constructs, the cost–benefit ratio of combining them into a composite score must be carefully considered given the potentially significant implications for respondent burden, the number of patients needed given a specified effect size and the associated costs. Thus, in the case of the Asthma Module, for example, while there may be a rationale for combining the Asthma Symptoms Scale and the Asthma Treatment Problems Scale into a single composite score, Vickers' statistical efficiency strategy might inform the decision-making process by demonstrating the relative effect sizes for either the Scales individually or as a combined subscale composite score based on the existing data from these Asthma Module Scales. It is likely that for a clinical trial concerned with asthma symptom control, utilizing the Asthma Symptoms Scale as the primary outcome would be more conceptually precise and would also demonstrate greater statistical efficiency than creating a composite score by combining two subscales.

To conclude, the PedsQL Disease and Condition Specific Modules have been developed to provide disease and condition-specific scales that can be individually utilized for a particular randomized trial, rather than necessitating the costs and respondent burden of requiring that all of the scales in a particular module be included. This flexibility is meant to increase the efficiency of the PedsQL Measurement Model in determining the efficacy and effectiveness of an intervention with an integrated set of generic and disease-specific HRQOL measures.

Some of the published data on each of the Scales of the existing PedsQL Disease and Condition Specific Modules are illustrated in TABLE 2. It describes the number of items per scale, the number of participants in these published studies, the means and standard deviations, Cronbach-a internal consistency reliability coefficients and intercorrelations between the module scales with the PedsQL 4.0 Generic Core Scales Total Scale

Table 2. PedsQL™ disease and condition specific modules: scale descriptives, internal consistency reliabilities, and intercorrelations with the PedsQL™ 4.0 Generic Core Scales Total Scale Score for child self report (ages 5–18) and parent proxy-report (ages 2–18).

		Number of items	n	Mean	SD	Cronbach-α	Intercorrelations with PedsQL™ 4.0 total scale score
Asthma Module[‡]							
Child self report	Asthma symptoms	11	274	64.15	19.22	0.86	0.55
	Treatment problems	11	276	80.55	14.23	0.69	0.50
	Worry	3	151	76.32	21.86	0.72	0.53
	Communication	3	152	73.68	24.85	0.70	0.39
Parent proxy report	Asthma symptoms	11	483	63.26	21.44	0.91	0.62
	Treatment problems	11	484	77.29	17.23	0.82	0.59
	Worry	3	150	77.39	22.38	0.82	0.49
	Communication	3	149	71.36	26.90	0.88	0.36
Arthritis/rheumatology Module							
Child self report	Pain and hurt	4	231	61.87	28.31	0.86	0.69
	Daily activities	5	231	90.09	15.00	0.78	0.55
	Treatment	7	230	77.97	19.62	0.80	0.51
	Worry	3	213	74.16	25.17	0.75	0.46
	Communication	3	231	70.53	26.94	0.78	0.49
Parent proxy report	Pain and hurt	4	242	61.93	28.25	0.91	0.69
	Daily activities	5	241	86.30	22.11	0.91	0.46
	Treatment	7	241	74.58	20.28	0.82	0.50
	Worry	3	232	78.70	23.69	0.83	0.53
	Communication	3	232	72.22	27.58	0.89	0.46
Cancer Module							
Child self report	Pain and hurt	2	219	76.20	25.21	0.70	0.51
	Nausea	5	220	75.81	22.68	0.79	0.49
	Procedural anxiety	3	219	68.26	30.67	0.82	0.34
	Treatment anxiety	3	219	82.19	24.78	0.79	0.42
	Worry	3	217	70.08	26.97	0.74	0.46
	Cognitive problems	5	218	70.46	22.00	0.76	0.57
	Physical appearance	3	216	70.33	23.99	0.49	0.46

Higher values indicate better health-related quality of life (fewer symptoms and problems).

*All intercorrelations significant at $p < 0.05$. Correlations between Disease and Condition Specific Module Scales and PedsQL™ 4.0 Total Scale Score for Cardiac Module and Diabetes Module are not contained in the published manuscripts.

‡Asthma sample data for the Asthma Symptoms Scale and Treatment Problems Scale includes reliability data from Chan KS and colleagues (2005). The PesQL™: reliability and validity of the Short Form Generic Core Scales and Asthma Module in children with asthma. Medical Care, 43, 256–265.

§Multidimensional Fatigue Scale values are for children with cancer only. Multidimensional Fatigue Scale data for pediatric/rheumatology in Varni JW, Burwinkle T, Brown J, Szer I (2004). The PedsQL™ Multidimensional Fatigue Scale in pediatric rheumatology: reliability and validity. Journal of Rheumatology, 31(12), 2494–2500.

Table 2. PedsQL™ disease and condition specific modules: scale descriptives, internal consistency reliabilities, and intercorrelations with the PedsQL™ 4.0 Generic Core Scales Total Scale Score for child self report (ages 5–18) and parent proxy-report (ages 2–18) (cont.).

		Number of items	n	Mean	SD	Cronbach-α	Intercorrelations with PedsQL™ 4.0 total scale score
	Communication	3	220	74.36	24.76	0.66	0.45
Parent proxy report	Pain and hurt	2	333	74.74	25.77	0.85	0.63
	Nausea	5	333	77.78	23.78	0.89	0.60
	Procedural anxiety	3	333	60.26	32.86	0.93	0.31
	Treatment anxiety	3	334	71.53	27.62	0.91	0.45
	Worry	3	331	75.92	28.35	0.90	0.47
	Cognitive problems	5	332	74.00	22.17	0.85	0.51
	Physical appearance	3	333	76.21	25.00	0.81	0.45
	Communication	3	327	78.31	23.55	0.83	0.37
Cardiac Module							
Child self report	Heart problems–symptoms	7	248	76.02	17.03	0.73	0.68
	Physical appearance	3	239	79.34	25.33	0.73	0.35
	Treatment anxiety	4	247	82.26	22.20	0.85	0.39
	Cognitive problems	5	245	75.66	20.59	0.77	0.63
	Communication	3	217	78.84	23.00	0.72	0.37
Parent proxy report	Heart problems-symptoms	7	343	79.60	17.62	0.83	0.71
	Physical appearance	3	336	82.90	22.96	0.81	0.49
	Treatment anxiety	4	338	71.24	28.84	0.95	0.35
	Cognitive problems	5	338	71.23	25.73	0.90	0.71
	Communication	3	273	74.59	26.76	0.89	0.41
Diabetes Module							
Child self report	Diabetes symptoms	11	147	65.31	15.79	0.81	0.66
	Treatment barriers	4	146	73.72	20.91	0.66	0.57
	Treatment adherence	7	145	80.81	15.50	0.66	0.63
	Worry	3	145	71.54	22.48	0.63	0.44
	Communication	3	143	74.07	25.08	0.77	0.52
Parent proxy report	Diabetes symptoms	11	158	63.96	13.37	0.81	0.54
	Treatment barriers	4	157	66.44	19.99	0.68	0.55

Higher values indicate better health-related quality of life (fewer symptoms and problems).

*All intercorrelations significant at $p < 0.05$. Correlations between Disease and Condition Specific Module Scales and PedsQL™ 4.0 Total Scale Score for Cardiac Module and Diabetes Module are not contained in the published manuscripts.

‡Asthma sample data for the Asthma Symptoms Scale and Treatment Problems Scale includes reliability data from Chan KS and colleagues (2005). The PesQL™: reliability and validity of the Short Form Generic Core Scales and Asthma Module in children with asthma. Medical Care, 43, 256–265.

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Table 2. PedsQL™ disease and condition specific modules: scale descriptives, internal consistency reliabilities, and intercorrelations with the PedsQL™ 4.0 Generic Core Scales Total Scale Score for child self report (ages 5–18) and parent proxy-report (ages 2–18) (cont.).

		Number of items	n	Mean	SD	Cronbach-α	Intercorrelations with PedsQL™ 4.0 total scale score
	Treatment adherence	7	158	76.74	17.13	0.73	0.45
	Worry	3	156	68.24	24.26	0.81	0.35
	Communication	3	156	64.90	25.98	0.84	0.41
Cerebral Palsy Module							
Child self report	Daily activities	9	76	73.94	29.78	0.93	0.65
	School activities	4	76	77.14	27.46	0.78	0.57
	Movement and balance	5	74	77.04	24.56	0.81	0.59
	Pain and hurt	4	71	73.59	23.13	0.77	0.53
	Fatigue	4	73	68.09	21.45	0.63	0.45
	Eating activities	4	71	88.57	21.30	0.79	0.45
	Speech and communication	4	71	82.89	21.55	0.80	0.31
Parent proxy report	Daily activities	9	235	36.93	32.87	0.96	0.49
	School activities	4	174	46.81	33.86	0.90	0.45
	Movement and balance	5	242	49.26	31.01	0.89	0.47
	Pain and hurt	4	233	65.28	25.89	0.88	0.47
	Fatigue	4	239	58.99	25.13	0.91	0.54
	Eating activities	4	235	63.86	35.03	0.91	0.39
	Speech and communication	4	173	56.79	35.63	0.95	0.38
Multidimensional Fatigue Scale[§]							
Child self report	Total fatigue	18	220	70.98	18.20	0.89	0.73
	General fatigue	6	220	74.99	19.59	0.77	0.67
	Sleep/rest fatigue	6	220	67.03	23.08	0.78	0.58
	Cognitive fatigue	6	220	70.92	22.35	0.83	0.59
Parent proxy report	Total fatigue	18	337	75.67	17.74	0.92	0.79
	General fatigue	6	337	73.62	20.92	0.88	0.78
	Sleep/rest fatigue	6	337	74.26	21.59	0.85	0.72
	Cognitive fatigue	6	337	79.14	21.69	0.93	0.48

Higher values indicate better health-related quality of life (fewer symptoms and problems).

*All intercorrelations significant at $p < 0.05$. Correlations between Disease and Condition Specific Module Scales and PedsQL™ 4.0 Total Scale Score for Cardiac Module and Diabetes Module are not contained in the published manuscripts.

†Asthma sample data for the Asthma Symptoms Scale and Treatment Problems Scale includes reliability data from Chan KS and colleagues (2005). The PesQL™: reliability and validity of the Short Form Generic Core Scales and Asthma Module in children with asthma. Medical Care, 43, 256–265.

§Multidimensional Fatigue Scale values are for children with cancer only. Multidimensional Fatigue Scale data for pediatric/rheumatology in Varni JW, Burwinkle T, Brown J, Szer I (2004). The PedsQL™ Multidimensional Fatigue Scale in pediatric rheumatology: reliability and validity. Journal of Rheumatology, 31(12), 2494–2500.

Score (based on the conceptualization of disease-specific symptoms as causal indicators of generic HRQOL [44]). Greater detail on the measurement properties of each of the Modules is contained in the published peer-reviewed journal articles cited in the reference list, including age-specific findings. These modules are briefly described next.

PedsQL™ 3.0 Asthma module

The 28-item multidimensional PedsQL 3.0 Asthma Module encompasses four scales:

- Asthma symptoms (11 items)
- Treatment problems (11 items)
- Worry (three items)
- Communication (three items)

The PedsQL 3.0 Asthma Module Worry and Communication Scales were adapted from previous PedsQL disease-specific modules. The Asthma Symptoms and Treatment Problems Scales were developed through focus groups, cognitive interviews, pretesting and field testing measurement development protocols. The Asthma Symptoms Scale includes such items as 'It is hard to take a deep breath'; 'I feel wheezy'; 'My chest hurts or feels tight'; 'I cough'; 'I get out of breath'. The Treatment Problems Scale includes such items as 'My medicines make me feel sick'; 'I have trouble using my inhaler'; 'I forget to take my medicines'; 'I don't like to carry my inhaler'.

PedsQL™ 3.0 Arthritis/Rheumatology Module

The 22-item multidimensional PedsQL 3.0 Arthritis/Rheumatology Module Scales encompass:

- Pain and hurt (four items)
- Daily activities (five items)
- Treatment (seven items)
- Worry (three items)
- Communication (three items)

Development of the PedsQL 3.0 Rheumatology Module was informed by the authors' instrument development research with the Pediatric Pain Questionnaire [10] and their arthritis-specific functional status measure [64], as well as earlier iterations of the PedsQL pretested in pediatric rheumatology. Parent proxy-report for the toddler age range (ages 2–4 years) does not include the Worry and Communication Scales since the cognitive interviews indicated that parents were not able to ascertain these constructs in children at this developmental stage. The Rheumatology Module Scales include such items as 'I ache or hurt in my joints and/or muscles'; 'I have trouble eating with a fork and knife'; 'My medicines make me feel sick'; 'I worry about my illness'.

PedsQL™ 3.0 Cancer Module

The 27-item multidimensional PedsQL 3.0 Cancer Module Acute and Standard Versions encompasses eight scales:

- Pain and hurt (two items)
- Nausea (five items)
- Procedural anxiety (three items)
- Treatment anxiety (three items)
- Worry (three items)
- Cognitive problems (five items)
- Perceived physical appearance (three items)
- Communication (three items)

Development of the PedsQL 3.0 Cancer Module was informed by our instrument development research with the Pediatric Cancer Quality of Life Inventory [65], the PedsQL™ 1.0 Cancer Module [6], as well as iterations of the PedsQL pretested in pediatric cancer. The Cancer Module Scales include such items as 'I hurt a lot'; 'I become sick to my stomach when I have medical treatment'; 'I get scared when I have to have blood tests'; 'I worry about the side effects from medical treatments'; 'It is hard for me to pay attention to things'; 'I don't like other people to see my scars'.

The PedsQL™ 3.0 Type 1 Diabetes Module

The 28-item multidimensional PedsQL 3.0 Diabetes Module encompasses five scales:

- Diabetes symptoms (11 items)
- Treatment barriers (four items)
- Treatment adherence (seven items)
- Worry (three items)
- Communication (three items)

The Diabetes Module Scales were developed through focus groups, cognitive interviews, pretesting, and field testing measurement development protocols. They include such items as 'I feel thirsty'; 'I get irritable'; 'It is hard for me to take insulin shots'; 'It is hard for me to exercise'; 'I worry about long-term complications from diabetes'.

The PedsQL™ 3.0 Cardiac Module

The 27-item multidimensional PedsQL 3.0 Cardiac Module encompasses six scales:

- Heart problems and treatment (seven items)
- Treatment II (five items)
- Perceived physical appearance (three items)
- Treatment anxiety (four items)
- Cognitive problems (five items)
- Communication (three items)

The Cardiac Module Scales were developed through focus groups, cognitive interviews, pretesting and field testing measurement development protocols. They include such items as 'My chest hurts or feels tight when I do sports activity or exercise'; 'I wake up at night with trouble breathing'; 'My heart medicine makes me feel sick'; 'It is hard for me to remember what I read'.

The PedsQL™ 3.0 Cerebral Palsy Module

The 35-item PedsQL 3.0 Cerebral Palsy Module encompasses seven Scales:

- Daily activities (nine items, e.g., 'It is hard for me to button my shirt')
- School activities (four items, e.g., 'It is hard for me to use a mouse for the computer')
- Movement and balance (five items, e.g., 'It is hard for me to move one or both of my legs')
- Pain and hurt (four items, e.g., 'I ache or hurt in my joints and/or muscles')
- Fatigue (four items, e.g., 'I feel tired')
- Eating activities (five items, e.g., 'It is hard for me to eat with a spoon and/or fork')
- Speech and communication (four items, e.g., 'It is hard for other people to understand my words')

The PedsQL 3.0 Cerebral Palsy Module was developed based on our research and clinical experiences with cerebral palsy and other chronic conditions, and the instrument development literature.

PedsQL Multidimensional Fatigue Scale

The 18-item PedsQL Multidimensional Fatigue Scale encompasses the three following scales and a Total Scale Score:

- General Fatigue Scale (six items, e.g., 'I feel tired'; 'I feel too tired to do things that I like to do')
- Sleep/Rest Fatigue Scale (six items, e.g., 'I feel tired when I wake up in the morning'; 'I rest a lot')
- Cognitive Fatigue Scale (six items, e.g., 'It is hard for me to keep my attention on things'; 'It is hard for me to think quickly')

The Scales were developed through focus groups, cognitive interviews, pretesting and field testing measurement development protocols. In addition to the application of the Multidimensional Fatigue Scale in pediatric cancer (acute version, 7-day recall period), the standard 1-month version has also been field tested in pediatric rheumatology.

The PedsQL & access/barriers to healthcare & quality of healthcare

HRQOL has been recognized as an important outcome, some contend the most important outcome, for children's healthcare interventions. The PedsQL 4.0 Generic Core Scales have been shown to be related to a number of other important healthcare constructs. Evidence of these associations provides further evidence for the PedsQL construct validity in healthcare settings.

Access/barriers to healthcare

Data from California's State Children's Health Insurance Program (SCHIP) suggest that children's HRQOL is related to access to needed care. In a survey of more than 10,000 recent SCHIP enrollees, children whose parents reported not getting care when needed, or who reported problems getting care, had PedsQL 4.0 scores approximately 4.5 points (MCID) lower than those with realized access to care [11]. Follow-up analyses showed that this relationship held true over time, even after controlling for baseline HRQOL (unpublished observations).

The PedsQL 4.0 has also been shown to be related to barriers to care [45]. In a sample drawn from the community and from two medical specialty clinics (hematology-oncology and rheumatology), the PedsQL 4.0 was shown to be related to the Barriers to Care Questionnaire, a measure designed to assess parents perceptions of various barriers to medical care [45].

In view of these findings, and in recognition of the fact that asthma, although a controllable disease, is a key source of morbidity and a growing cause of mortality for children, a current clinical trial is under way, using the PedsQL 4.0 as the primary outcome measure. This behavioral clinical trial compares usual care with asthma home visit-based care coordination to a combined intervention that includes both the care coordination and problem-solving skills training. Families of children with asthma are being recruited from community health centers (primary care clinics that serve mostly uninsured or underinsured children), schools and private pediatric practices. Other outcomes to be measured include frequency of symptoms and healthcare utilization. This federally funded clinical trial is currently in year 2 of a 4-year grant.

Quality of healthcare

The PedsQL 4.0 has also been shown to be related to pediatric primary care quality as measured by the Parent's Perceptions of Primary Care measure (P3C), a survey designed to assess parents' reports of their child's primary care experiences [46]. The P3C was designed to reflect the Institute of Medicine's definition of primary care and is based on parent reports of experiences that constitute high-quality primary care. Using a large urban community sample, P3C scores were used to split the sample into three tertiles and these three groups were compared on their PedsQL 4.0 scores. A one-way analysis of variance indicated that the differences among these means were statistically significant ($F(2,3260) = 40.94$; $p < 0.001$). Furthermore, post-hoc tests showed that the highest tertile P3C group (PedsQL mean = 80.24; standard deviation [SD] = 16.29) had significantly higher PedsQL 4.0 scores than did the lowest (mean = 74.29; SD = 16.91) and middle (mean = 75.07; SD = 16.78) tertiles, which were not significantly different from one another. Furthermore, a recent study by the RAND Corporation [52] illustrates the utility of the PedsQL 4.0 to detect improvements in quality of clinical care.

Expert commentary

The PedsQL in pediatric clinical practice

Findings from the adult literature suggest that routine implementation of standardized HRQOL screening may be a necessary but insufficient condition for enhancing patients' HRQOL [66]. Incorporating specific resource management suggestions, such as appropriate referrals and tailored treatments, are hypothesized to enhance the efficacy of HRQOL

measurement by providing physicians and other healthcare professionals with viable options to identified problems [66]. Thus, research on the integration of HRQOL measurement into clinical practice has demonstrated that the provision of HRQOL data to physicians is more likely to impact detection and diagnosis, but is generally not sufficient to change physicians' management behaviors unless the HRQOL findings are linked to the available resources necessary to improve HRQOL outcomes [66]. The general failure to produce changes in treatment may be related to physician's limited experience with such measures or the difficulty of healthcare professionals in translating HRQOL data into specific interventions to improve functioning. Furthermore, there may be significant barriers to the implementation of HRQOL measures into clinical practice. Barriers such as perceived lack of time, money and human resources needed to collect, analyze and interpret HRQOL data, as well as the lack of ongoing computer support for storing and retrieving data, can greatly impede implementation of routine HRQOL measurement in clinical practice [66]. Therefore, while HRQOL measurement logically appears to have potential utility in pediatric clinical practice, there are a number of perceived barriers to use that must be addressed.

The realities of today's healthcare industry mandates that any change to current standard practice demonstrate that the change does not cost the organization more in resources or, ideally, saves the organization costs in the future. In order to optimize the finite resources within the pediatric healthcare system, identifying pediatric patients with poor HRQOL and deploying appropriate interventions might result in lower long-run costs by preventing future inappropriate use of healthcare services (e.g., using the Emergency Department for routine or urgent care). Identifying, in a timely manner, pediatric patients with low HRQOL can be hypothesized to enable healthcare providers to target scarce resources perhaps more effectively. Unfortunately, the evidence for these hypotheses in the pediatric literature is mostly unavailable [66].

As previously suggested [66], the authors hypothesize that the overarching precept for determining the likely implementation of HRQOL measurement in pediatric clinical practice requires a win-win circumstance, that is, by helping children to optimize their HRQOL, the organization actually saves healthcare costs in the future, or at the very least, finds the change 'revenue neutral' (i.e., the change pays for itself somehow). Convincing healthcare systems to implement a change that has upfront costs is challenging at best. Pediatric healthcare systems often find themselves struggling to survive. Without clear economic value, as perceived by senior management, or regulatory or legislative mandate, changes in healthcare systems are rarely accomplished.

Nevertheless, a recent PedsQL 4.0 Generic Core Scales study provides data that are suggestive of the potential for cost savings. The objective of the study was to test the hypothesis that parent proxy report of pediatric HRQOL would prospectively predict pediatric healthcare costs over a 2-year period in 317 children aged 2–18 years. Participants were members of a managed care health plan with prospective payment. In this study, the PedsQL 4.0 Generic Core Scales prospectively accounted for significant variance in healthcare costs at 6, 12 and 24 months [47]. Adjusted regression models that included both PedsQL 4.0 scores and chronic health condition status accounted for 10.1, 14.4 and 21.2% of the variance in healthcare costs at 6, 12 and 24 months, respectively. PedsQL scores and chronic health condition status together defined a high-risk group, constituting 8.7% of the sample and accounting for 37.4, 59.2 and 62% of healthcare costs at 6, 12 and 24 months. The high-risk group's per member per month healthcare costs were, on average, 12-times that of other enrollees' at 24 months. While this example is very selective and preliminary, it nevertheless supports further testing of the hypothesis that PedsQL measurement at the point of care can both be the right thing to do for kids while not necessarily being a financial burden to the healthcare system, and may even save the healthcare system costs in the future.

Therefore, being able to demonstrate the utility of pediatric HRQOL measurement in identifying children with the greatest needs, while simultaneously demonstrating the cost advantages of providing timely, targeted interventions to address those needs, may ultimately provide the driving force for incorporating PedsQL measurement into pediatric clinical practice. Research projects to test this hypothesis are currently in the planning stages.

PedsQL in pediatric chronic disease management

Given initial empiric evidence that pediatric patients with chronic health conditions and low PedsQL scores comprise a subgroup of patients at risk for high healthcare costs in the future [47], the next step required is to design interventions at the point of care that will address the deficits in HRQOL that are amendable to intervention.

Chronic disease management consists of an integrated approach involving routine assessment and proactive management of high-risk patients. PedsQL measurement at the point of care could facilitate communication between patients/parents and physicians by providing a systematic assessment of patient and parent perceptions of the child's current functioning. Since many children may not have the language skills necessary to accurately communicate their symptoms or feelings verbally when asked by their physician, 'How are you doing?', scores on the PedsQL may indicate problem areas for further exploration unrelated to the chief complaint but which otherwise indicate a negative impact on patient HRQOL.

The PedsQL could also be used to tailor interventions to the specific needs of the child or family. Using PedsQL disease-specific modules, disease management interventionists could quickly gain an appreciation of the family's current difficulties and target educational, behavioral and/or pharmaceutical interventions appropriately. This approach is likely to increase the efficiency and efficacy of such interventions.

A recent PedsQL study by the RAND Corporation [52] illustrates the possibility of pediatric disease management with the PedsQL as a primary outcome measure. Specifically, Mangione-Smith and colleagues conducted a national effectiveness trial in pediatric asthma following the Chronic Care Model and the Breakthrough Series collaborative team approach [52]. The Chronic Care Model identifies six elements of the healthcare system such as organization/leadership, patient self-management, delivery system design, healthcare provider decision support, informational technology, and links to community resources that can be utilized to optimized chronic disease care [52]. The Breakthrough Series collaborative process emphasizes a team approach to continuous quality improvement in patient chronic disease management [52]. In the RAND study [52], pediatric patients with asthma receiving care from clinics participating in the collaborative intervention had significant improvements in processes of care variables, such as monitoring their peak flows and having a written asthma action care plan. Patients in the intervention group demonstrated higher generic and asthma-specific scores on the PedsQL™ 4.0 SF-15 Generic Core Scales and the PedsQL™ 3.0 SF-22 Asthma Module [2,5]. This real-world effectiveness trial lends further support to the potential utility of the PedsQL as the HRQOL outcome measure in clinical practice settings.

Five-year view

Perhaps the time will finally arrive in the next 5 years to consider pediatric patients' and parents' perceptions of the child's health and well-being as essential outcomes in the evaluation of the quality of care provided. The following quote from a recent article on patient safety may arguably be interpreted as suggestive of the importance of considering patient HRQOL measurement within the realm of patient safety. Leape and Berwick [67] propose that the boundaries among overuse (receiving treatment of no value), underuse (failing to receive needed treatment) and misuse (errors and defects in treatment) [68] have blurred. "It seems logical that patients who fail to receive needed treatments or who are subjected to the risks of unneeded care are also placed at risk for injury every bit as objectionable as direct harm from surgical mishap. Importantly, it is much clearer now that the most effective method to improve either safety or quality overall is to change the system." [67]. We suggest that part of the process of changing the system includes measuring HRQOL outcomes from the perspective of children and their parents on a routine basis, consistent with a consumer-based healthcare approach.

How can HRQOL outcomes be incorporated into healthcare and change the system? We propose that the advent of the electronic medical record (EMR) provides the opportunity for the integration of HRQOL outcomes as a quality indicator of the appropriateness and safety of the care provided. Specifically, over the next 5 years we plan to develop and test ideas that build on the existing empiric literature, and then leap several steps further.

Key issues

- The PedsQL™ Measurement Model was designed as a modular approach to measuring pediatric health-related quality of life, developed to integrate the relative merits of generic and disease-specific approaches.
- The PedsQL 4.0 Generic Core Scales have consistently demonstrated on over 25,000 children and their parents in over 75 peer-reviewed journal publications in numerous pediatric chronic health conditions the feasibility, reliability, validity, sensitivity and responsiveness required for a patient-reported outcome for pediatric clinical trials in child self-report ages 5–18 years and parent proxy report for ages 2–18 years.
- The PedsQL 4.0 is the only empirically validated generic pediatric health-related quality of life measurement instrument available to span this broad age range for child self-report and parent proxy report while maintaining item and scale construct consistency.
- The PedsQL 4.0 Generic Core Scales have been translated into over 60 languages.
- The PedsQL Disease and Condition Specific Modules are designed to measure health-related quality of life dimensions specifically tailored for pediatric chronic health conditions, and include the PedsQL Asthma, Arthritis/Rheumatology, Cancer, Diabetes, Cardiac and Cerebral Palsy Modules, as well as the generic PedsQL Multidimensional Fatigue Scale, Pediatric Pain Questionnaire™, Family Impact Module and Healthcare Satisfaction Module.
- The PedsQL has been shown to be related to other key constructs in pediatric healthcare such as access to needed care, healthcare barriers and quality of primary care.
- The PedsQL has been empirically demonstrated to predict prospectively pediatric healthcare utilization and costs over an extended period.
- Future advances in the PedsQL Measurement Model include web-based electronic administration (ePedsQL™), integration into the electronic medical record, further efficacy and effectiveness outcome trials, including PedsQL ResourceConnect℠ and PedsQL Tailored Interactive Problem Solving℠, and development of the generic PedsQL Infant Scales for ages birth to 24 months and additional modules for other pediatric chronic health conditions.

- We are currently testing the electronic administration of the PedsQL™ (ePedsQL™). This application is designed as a web-based instrument that will allow for instant scoring and reporting in comparison to the existing PedsQL™ Database℠, with new data constantly being added. It is anticipated that this application will be implemented in pediatric healthcare settings, and schools, along with known risk factors assessment.

- We are in the planning stages of designating the PedsQL 4.0 Generic Core Scales as the quality indicator for a large Department of Pediatrics. Two constructs, PedsQL Resource-Connect℠ and PedsQL TIPS℠, will be field tested to address the limitations in the empiric investigation of HRQOL measurement in pediatric clinical practice.
- PedsQL ResourceConnect℠ will entail the systematic linking of referral resources to point of service PedsQL scores. Specifically, when a child scores below the PedsQL cut-off points for 'at risk' status, the child's physician will be notified, with a recommended referral source linked to the specific problems identified on the PedsQL™.
- PedsQL TIPS℠ will consist of Tailored Interactive Problem Solving℠ strategies designed to target specific symptoms and problems identified by PedsQL disease and condition specific modules. It will also involve teaching problem-solving skills to pediatric patients and their parents specific to the symptoms and problems identified by PedsQL™. This brief, tailored intervention will then be compared with the healthcare outcomes and costs for standard care.
- Both PedsQL ResourceConnect and PedsQL TIPS are designed to address the need to provide physicians and healthcare providers with actionable steps in response to PedsQL identified problem areas. Thus, the integration of PedsQL instruments with PedsQL ResourceConnect and PedsQL TIPS is hypothesized to overcome the barriers previously identified in the literature to the implementation of HRQOL instruments in clinical practice.
- To expand the age reach of the PedsQL, we are currently planning the development of the PedsQL Infant Scales for ages birth–24 months. We will be initially assessing healthy infants, infants diagnosed with cancer and infants in neonatal intensive care units and out-patient specialty clinics.

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