

## Electronic Versus Paper Questionnaires: A Further Comparison in Persons with Asthma

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### ABSTRACT

The use of electronic data capture (EDC) to assess health-related quality of life (HRQOL) using validated questionnaires is increasing; however, it must be determined how data collected electronically correlate with the original mode of administration used in validation. Our objective was to compare paper and electronic administration of the standardized Asthma Quality of Life Questionnaire (AQLQ(S)), Pediatric Asthma Quality of Life Questionnaire (PAQLQ(S)), and Pediatric Asthma Caregiver's Quality of Life Questionnaire (PACQLQ). Using a crossover design, adults and children with asthma and caregivers of children with asthma were recruited from clinics. Subjects were asked to complete both forms of the appropriate HRQOL measures at enrollment and 24–48 hours later. In addition, 30 subjects from each group were asked to participate in a 1-week reproducibility assessment of the electronic versions of the three questionnaires. Psychometric properties were assessed for each of the EDC versions. Intraclass correlation coefficients (ICC) and Pearson correlations were calculated to compare EDC and paper versions. A total of 51 adults (mean age 37, 73% females), 52 children (mean age 13, 38% females), and 51 caregivers (mean age 43, 92% females) were evaluated. Internal consistency (Cronbach's alpha) for the overall score of each questionnaire was: 0.96 for the AQLQ(S) and the PAQLQ(S), and 0.92 for the PACQLQ. Overall ICCs comparing paper with EDC were: 0.96 for the AQLQ(S), 0.91 for the PAQLQ(S), and 0.82 for the PACQLQ. Pearson's correlations were identical. One-week reproducibility (ICC) of the EDC versions was: 0.88 for the AQLQ(S), 0.78 for the PAQLQ(S), and 0.85 for the PACQLQ. When asked which method subjects preferred, the electronic version was chosen by 69% of adults, 77% of children, and 73% of caregivers. Additionally, 14% of adults, 14% of children, and

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54 18% of caregivers reported no difference in preference. As in previous studies compar-  
 55 ing electronic with paper questionnaires, this study revealed statistical evidence to  
 56 support the use of EDC of the AQLQ(S), PAQLQ(S), and PACQLQ for populations  
 57 with asthma.

58  
 59 *Key Words:* Asthma; EDC; Electronic assessment; AQLQ(S); PAQLQ(S); PACQLQ;  
 60 Quality of life.

## 61 62 INTRODUCTION

63  
 64 To date, health-related quality of life (HRQOL)  
 65 research has predominately been conducted with the  
 66 use of paper-and-pencil questionnaires. However, as  
 67 computers become smaller and hand-held units more  
 68 prevalent, a greater number of studies are using  
 69 developing technology in what is termed as electronic  
 70 data capture (EDC) to eliminate the need for lengthy  
 71 or cumbersome paper surveys. EDC offers many  
 72 benefits, including personalization of questionnaires  
 73 both to study protocols and specific populations,  
 74 automatic date stamping, programmable skip  
 75 patterns, and immediate data entry, which eliminates  
 76 the possibility of entry errors that may be made  
 77 manually. Several recent studies have been conducted  
 78 to test for differences between the traditional paper-  
 79 and-pencil and EDC, all concluding that data col-  
 80 lected electronically is more complete (1), equivalent  
 81 (2), reliable (3), and cost-effective (4–7).

82  
 83 It is well-known that the symptoms of asthma—  
 84 wheezing, coughing, and shortness of breath—cause  
 85 a significant patient burden both in children and  
 86 adults (8). These symptoms not only interfere with  
 87 physical activities, but also affect feelings of frustra-  
 88 tion, fear, and other areas of HRQOL not only of the  
 89 individual, but also of significant others around the  
 90 individual (9). To evaluate asthma-specific changes  
 91 in patient quality of life, three standardized measures  
 92 were identified: the standardized Asthma Quality of  
 93 Life Questionnaire (AQLQ(S)) (10,11), Pediatric  
 94 Asthma Quality of Life Questionnaire (PAQLQ(S))  
 95 (12), and Pediatric Asthma Caregiver's Quality of  
 96 Life Questionnaire (PACQLQ) (13). All three  
 97 measures are commonly used in adult and pediatric  
 98 asthma clinical trials. However, only one of these  
 99 measures (the AQLQ(S)) has had any validation  
 100 work published that would present satisfactory  
 101 claims of equal performance in electronic mode  
 102 (14). Therefore, the objective of this study was to  
 103 establish the validity of the electronic versions of  
 104 the AQLQ(S), PAQLQ(S), and the PACQLQ in com-  
 105 parison with the existing paper versions. A secondary  
 106 objective of the study was to compare the ease of use

and preference for mode of administration of the paper  
 and electronic versions of the three questionnaires.

## METHODOLOGY

### Study Design

The study used an open, randomized, two-period  
 crossover design with the two modes of administra-  
 tion (paper followed by EDC, and EDC followed by  
 paper) allocated in a predetermined random order.  
 Each enrollee was given the appropriate measure  
 twice (upon enrollment and then a second time as  
 close to within 24 hours later as possible). The three  
 measures were evaluated in clinical settings on three  
 separate groups of 50 patients each. Of the 150 total  
 participants, 50 adults with asthma were asked to  
 complete the AQLQ(S), 50 children with asthma  
 were given the PAQLQ(S), and 50 caregivers of  
 children with asthma were asked to complete the  
 PACQLQ. To evaluate the reproducibility of the  
 electronic versions, a retest of the electronic version  
 was administered 7 days later to the first 30 people  
 who consented from each of the three groups.

### Recruitment

The patient population was recruited through  
 health care providers at two separate clinical sites:  
 the National Jewish Medical and Research Center in  
 Denver, Colorado, and the North Carolina Clinical  
 Research Center in Raleigh, North Carolina.  
 Clinicians and their staff identified those patients  
 within their practice who met inclusion criteria and  
 spoke to them briefly about the study. If a patient  
 was interested in participating in the study, the  
 clinic staff explained the study in more detail and  
 offered the patient an opportunity to participate.  
 Reminder calls were made before each scheduled  
 visit. After successful enrollment of the patient, the  
 site staff added the patient to the weekly recruitment  
 report.

107 Children could be included in the study if they  
108 were between the ages of 7 and 17 and currently diag-  
109 nosed with asthma. Both adults with a current  
110 diagnosis of asthma and caregivers of asthmatic  
111 children with asthma were included in the study if  
112 they met the following requirements: (1) between  
113 the ages of 18 and 70, (2) were able to read and  
114 comprehend English at least at a sixth grade level,  
115 (3) were able to write sufficiently well to respond to  
116 the battery of measures, (4) were physically able to  
117 come to the recruitment location for their face-to-face  
118 interview, and (5) were willing to sign an informed  
119 consent document. Patients were excluded if they  
120 had a history of seasonal asthma, history of asth-  
121 matic conditions complicated by smoking, substance  
122 abuse, or any other extreme comorbidity. These  
123 conditions were deemed to present a possible bias  
124 to patient reference points when responding to the  
125 QOL measures, thereby potentially affecting psycho-  
126 metric performance differently.

127 Because this was a non-treatment study, no  
128 clinical criteria were used as inclusion or exclusion  
129 criteria. However, all participants were to be  
130 recruited from an asthma treatment clinic where  
131 they were receiving care for asthma, implying a  
132 current diagnosis. Each clinic submitted and received  
133 approval by their local Institutional Review Board to  
134 conduct this study.

### 135 136 137 **EDC Instrument** 138

139 The device and software for collecting the  
140 electronic data used in this study was designed by  
141 Assist Technologies of Scottsdale, Arizona, and  
142 featured a touch-screen display that could be used  
143 either with finger pressure or a stylus or light pen.  
144 The hardware was a network-ready fully integrated  
145 liquid crystal display touch-screen workstation. One  
146 question was displayed per screen, and after a  
147 response was entered, the next item automatically  
148 appeared. The participant had the option of skip-  
149 ping a question or returning and reviewing previous  
150 questions. Once complete, the electronic data were  
151 downloaded and transmitted to the coordinating  
152 center. The paper data were collected and edited at  
153 each site and shipped to the coordinating center,  
154 where it was audited for completeness and clarity,  
155 and entered using a centralized, stand-alone entry  
156 program with built-in range checking algorithms.  
157 Once entered, all data were then finalized and  
158 prepared for analysis including the scoring of all  
159 measures.

### **Measures and Measurement Events**

Each of the three groups (adults with asthma, children with asthma, and caregivers of children with asthma) was given the asthma-specific HRQOL measure appropriate for them—the AQLQ(S), PAQLQ(S), and PACQLQ, respectively. The AQLQ(S) includes 32 items (in four domains) covering areas of quality of life impairment that are important to adult asthmatic patients—activity limitation, symptoms, emotional function, and environmental stimuli. The PAQLQ(S) contains 23 items that children with asthma have identified as troublesome in their daily lives. It has three domains—activity limitation, symptoms, and emotional function. Finally, the PACQLQ contains 13 items in two domains—activity limitations and emotional function—aimed at parents and primary caregivers of children with asthma. It is given to measure impairments such as limitations in normal daily activities and anxieties and fears resulting from the child's illness. In addition to common demographic descriptors including age, gender, education, ethnicity, and a 4-point self-reported severity item, two visual analog scales (VAS) (one being a general evaluation of physical limitation and the other a general evaluation of distress) were designed to provide an independent point against which to assess the convergent associations of the two modes of administration (Appendix 1). A 15-point global rating of change item was used to identify those patients self-reporting high degrees of change in their health status during the retest period (Appendix 2). These items were incorporated into both the electronic and the paper versions. At the end of each administration (paper and EDC), there were two items at the conclusion of each patient's crossover visit to assess their preference between the two modes of administration (Appendix 3).

### **Data Analysis**

This study compares the two modes of administration to determine whether or not the electronic versions demonstrate a similar behavior to paper with respect to standard psychometric criteria. Any differences of 0.5 points or greater between the paper and EDC versions were considered clinically important (15). The specific analyses and cut points used were based upon the published standards of the Medical Outcomes Trust Group (16) for reliability

AQ1

160 (internal consistency and reproducibility), and cross-  
161 sectional construct (convergent and discriminant)  
162 validity. Longitudinal construct validity (responsive-  
163 ness) and effect size could not be evaluated in this  
164 study.

165 All analyses were conducted using the Statistical  
166 Package for the Social Sciences (SPSS) (17). Standard  
167 descriptive statistics were run on each of the mea-  
168 sures for each mode of administration in order to  
169 identify ranges (min–max) and the distributions of  
170 response choices. Means, standard deviations,  
171 medians, and percentages of missing data were com-  
172 puted for each item and distributions checked.  
173 Missing data were negligible across all measures  
174 and administrations. The paper version of the  
175 PAQLQ(S) yielded the highest amount of missing  
176 items (24 of 1196 possible: 2%).

### 177 178 179 **Reliability**

180  
181 To assess internal consistency for both the paper  
182 and electronic versions of each of the measures,  
183 Cronbach's alpha was used to analyze additive  
184 scales to determine if the items within the scale were  
185 highly associated (18). A high internal consistency  
186 suggests that the scale or subscale is measuring a  
187 single construct. A minimum correlation of 0.70  
188 is necessary to claim the instrument is internally  
189 consistent and alpha values between 0.85 and 0.95  
190 are preferred (19).

191 To evaluate the reproducibility of the electronic  
192 version of each asthma-specific HRQOL measure,  
193 the first 30 participants in each of the three  
194 groups were asked to return and complete a 1-week  
195 retest for the electronic version only. Test-retest  
196 reliability was assessed using the intraclass correla-  
197 tion coefficient (ICC) to evaluate the relationship  
198 between the baseline and 1-week measures. The  
199 ICC is the preferred measure of strength of asso-  
200 ciation for determining stability of scores over time,  
201 because it corrects for lack of independence between  
202 measurement intervals. The ICC ranges between  
203 0.00 and 1.00, and the minimal acceptable level is  
204 0.70. (16,20). In the previous developmental work,  
205 ICC values for the overall quality of life scores,  
206 for stable patients, were 0.92 for the AQLQ(S)  
207 (10,11), 0.95 for the PAQLQ(S) (12), and 0.84 for  
208 the PACQLQ (13). To account for any major  
209 change in the populations, the global rating of  
210 change question was recoded to assess those patients  
211 as unchanged ("About the same" and "Almost the  
212 same").

### **Validity**

To assess convergent validity, Pearson's correla-  
tions were computed to measure the association  
between the limitation and emotional subscales of  
each of the three QOL measures and the scores on  
the global VAS items that were written to address the  
same constructs. Convergent validity has already  
been established and reported for the paper version  
of each measure (11–13). In this comparison of paper  
and EDC measures, we will not endeavor to reesta-  
blish or discuss the merits of convergent association  
between the three asthma measures and other scales.  
Rather, we present the magnitude and significance  
of the associations for each pair of measures against  
an independent and logically related item designed to  
have some expected level of association with asthma-  
related limitations and distress. Our purpose is to  
evaluate and report the closeness of performance  
between the two modes of administration.

Assessing discriminant validity involves testing  
various hypotheses about how we intuitively believe  
the limitation scales should work. The standard  
approach using "known groups" was used for this  
analysis. The discriminant validity has already been  
published for the original paper version of each of  
these measures (11–13). In this study, we were look-  
ing for the similarity of discriminating performance  
between the two modes of administration for each  
measure against a common known groups metric.  
Self-reported levels of severity of asthma symptoms  
identified the groups.

### **Ease of Use and Preference**

At the crossover administration, patients were  
asked two questions: "Which method was easier to  
use?" and "If there were a choice, which method of  
completing the questionnaire would you prefer?"  
Each question had the following 3-point response  
scale: (1) paper and pencil, (2) computer, and (3) no  
difference. Percents of each were examined.

## **RESULTS**

As shown in Table 1, the sample of adults with  
asthma were, on average, 37 years old. The adult  
caregivers were slightly older (mean age of 43  
years). Both groups of adults were predominantly  
female, and, on average, had 15 years of education  
(some college). The children with asthma averaged

**T1**

**Table 1.** Demographic characteristics of the samples.

	Adults with asthma (n = 51)	Children with asthma (n = 52)	Caregivers of children with asthma (n = 51)
Age (mean years [SD])	37.3 (12.9)	12.9 (1.9)	43.1 (9.0)
Gender (% female)	72.5	38.5	92.2
Education (mean years [SD])	15.0 (2.0)	6.7 (2.1)	15.0 (2.1)
Ethnicity (% Caucasian)	92.2	71.2	72.5
Symptom severity	%	%	%
% None	23.5	38.5	15.7
% Mild	52.9	34.6	49.0
% Moderate	21.6	19.2	33.3
% Severe	0.0	1.9	2.0
% Missing	2.0	5.8	0.0

13 years of age, were predominantly male, and had a mean of just under 7 years of education.

Just over three quarters of the group of adults with asthma reported mild symptoms or no symptoms. It is interesting to note that the severity of asthma-specific symptoms was higher for mild and moderate symptoms as reported by the caregivers for the children (15.7% none, 49% mild, and 33.3% moderate) than it was by the children themselves (38.5% none, 38.5% mild, and 19.2% moderate).

To compare the performance of the paper and EDC version, Tables 2, 3, and 4 have been prepared to show the item-by-item differences in responses between the enrollment visit and the crossover visit 24 hours later. In each of these tables, the list of items in the measure are identified, followed by the Pearson correlation between the paper and EDC versions. The percent of participants registering the same response for each item at both enrollment and crossover is shown in a column in the center of the table, followed by a series of columns showing the number of units of change (using number of possible response options) registered by the remaining group of patients. For each measure, the amount of disparity between the enrollment response and the crossover response is concentrated within 1–3 units of change (out of 6 possible). Given that the target population was recruited from a clinic setting where they were undergoing current treatment for asthma, it is not surprising to have some amount of change within a 24-hour period. The relative lack of disparity registering at 5 and 6 units of change is an indication that the degree of change during the 24-hour period was probably as stable as it could be for this patient group, given the relative volatility of the condition.

Although differences occurred in all three populations, the pediatric patients were the most divergent, with several children indicating differences of 4, 5, and even 6 points between the paper and EDC administrations.

Mean score differences (Table 5) were evaluated between the two administrations. Scores from the AQLQ(S) were quite similar (differences ranging from 0.02 to 0.06) with all domains having non-significant *P* values and ICC values between 0.90 and 0.96, indicating like results. The PAQLQ(S) domain scores were comparable (differences ranging from 0.00 to 0.19) with ICC values between 0.89 and 0.93. The PACQLQ domain scores were all slightly higher using EDC but the differences were insignificant.

Table 6 shows the convergent validity between the two administrations and the external VAS. Correlations were similar across the administrations with the exception of the PACQLQ paper version (0.36). Significant differences were found between levels of severity (none, mild, moderate, severe) and the total scores of the AQLQ(S) (*P* < 0.001), the PAQLQ(S) (*P* < 0.001), and the PACQLQ (*P* < 0.05).

Test-retest reproducibility results for the EDC version were favorable (Table 7). One-week ICC values ranged from 0.81 to 0.90 for the AQLQ(S), from 0.66 to 0.80 for the PAQLQ(S), and from 0.78 to 0.85 for the PACQLQ. The average time between the EDC administrations was 7.1 ± 0.9 days for the AQLQ(S) and 6.8 ± 0.9 days for both the PAQLQ(S) and the PACQLQ.

On the evaluation questions given to each patient asking about the ease of use and preferred administration, the EDC version was predominantly chosen (Table 8). For the electronic version, 80.4% of adults,

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T2–T4

T6

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Table 2. AQLQ(S) item-by-item differences between paper and EDC.

AQLQ(S) items (each having a 7-point response scale)	Pearson corr.	% with same response	% patients differing by					
			1 unit	2 units	3 units	4 units	5 units	6 units
AQ1 Strenuous activities	0.75	58	36	4	2	0	0	0
AQ2 Moderate activities	0.81	74	18	4	4	0	0	0
AQ3 Social activities	0.82	62	34	2	2	0	0	0
AQ4 Work-related activities	0.83	70	24	6	0	0	0	0
AQ5 Sleeping	0.81	62	30	6	2	0	0	0
AQ6 Chest tightness	0.68	46	40	12	2	0	0	0
AQ7 Concerned about having asthma	0.78	48	42	8	2	0	0	0
AQ8 Short of breath	0.78	52	40	8	0	0	0	0
AQ9 Result of being exposed to smoke	0.78	50	32	16	0	2	0	0
AQ10 Wheeze	0.89	56	44	0	0	0	0	0
AQ11 Avoid a situation because of cigarette smoke	0.81	50	32	12	4	2	0	0
AQ12 Coughing	0.84	60	34	6	0	0	0	0
AQ13 Frustrated	0.78	50	34	14	2	0	0	0
AQ14 Chest heaviness	0.87	64	30	6	0	0	0	0
AQ15 Concerned about the need to use medication	0.84	52	38	10	0	0	0	0
AQ16 Clear your throat	0.77	46	44	6	4	0	0	0
AQ17 Result of being exposed to dust	0.88	56	40	4	0	0	0	0
AQ18 Difficulty breathing out	0.85	60	32	8	0	0	0	0
AQ19 Avoid a situation because of dust	0.89	56	42	0	2	0	0	0
AQ20 Wake up in the morning with asthma symptoms	0.81	48	42	8	0	0	2	0
AQ21 Afraid of not having medication available	0.91	56	40	4	0	0	0	0
AQ22 Heavy breathing	0.75	44	46	10	0	0	0	0
AQ23 Result of the weather or air pollution	0.81	48	38	12	2	0	0	0
AQ24 Woken at night	0.89	60	36	4	0	0	0	0
AQ25 Avoid going outside because of the weather	0.80	66	30	2	0	2	0	0
AQ26 Result of being exposed to strong smells	0.91	64	32	4	0	0	0	0
AQ27 Afraid of getting out of breath	0.76	46	42	12	0	0	0	0
AQ28 Avoid a situation because of strong smells	0.78	66	28	2	0	2	0	2
AQ29 Interfered with getting a good nights sleep	0.95	72	26	2	0	0	0	0
AQ30 Fighting for air	0.80	45	49	6	0	0	0	0
AQ31 Overall range of activities	0.81	54	34	12	0	0	0	0
AQ32 All the activities	0.81	62	34	4	0	0	0	0

Note: The figures are reported in percentages—and every 2% represents one person. Those registering change by 5 or 6 units are, in most cases, different people.

92.3% of children, and 88.3% of the caregivers stated the electronic method was easier to use (or that there was no difference) than the traditional paper and pencil version. Similarly, 69% of adults, 77% of children, and 73% of the caregivers preferred the EDC method over the paper.

## DISCUSSION

Rather than intending to assess validity of the original measures, this study aimed to assess the differences of two methods of administration of the AQLQ(S), PAQLQ(S), and PACQLQ: traditional

**Table 3.** PAQLQ(S) item-by-item differences between paper and EDC.

PAQLQ(S) items (each having a 7-point response scale)	Pearson corr.	% With same response	% Patients differing by					
			1 unit	2 units	3 units	4 units	5 units	6 units
AQ1 Physical activities	0.55	40	46	10	0	2	2	0
AQ2 Being with animals	0.51	54	22	12	8	2	2	0
AQ3 Activities with friends and family	0.63	52	28	16	4	0	0	0
AQ4 Coughing	0.70	46	32	14	4	4	0	0
AQ5 Frustrated	0.73	52	26	18	4	0	0	0
AQ6 Tired	0.64	36	34	28	0	2	0	0
AQ7 Worried, concerned or troubled	0.54	44	42	10	2	2	0	0
AQ8 Asthma attacks	0.69	56	33	4	4	0	2	0
AQ9 Angry	0.80	58	33	8	0	0	0	0
AQ10 Wheezing	0.67	48	42	6	2	0	2	0
AQ11 Irritable	0.85	50	44	2	4	0	0	0
AQ12 Tightness in your chest	0.81	51	43	4	2	0	0	0
AQ13 Feel different or left out	0.57	51	33	12	2	0	0	2
AQ14 Shortness of breath	0.68	35	46	15	4	0	0	0
AQ15 Frustrated not to keep up with others	0.79	55	31	10	4	0	0	0
AQ16 Wake up during the night	0.83	55	39	6	0	0	0	0
AQ17 Uncomfortable	0.48	46	38	6	8	0	2	0
AQ18 Out of breath	0.61	38	46	12	2	2	0	0
AQ19 You could not keep up with others	0.76	55	31	10	4	0	0	0
AQ20 Sleeping at night	0.65	59	27	12	0	0	0	2
AQ21 Frightened by an asthma attack	0.83	63	25	6	6	0	0	0
AQ22 How much were you bothered by asthma	0.71	34	56	8	0	2	0	0
AQ23 Difficulty taking a deep breath	0.68	45	41	10	0	2	0	2

Note: The figures are reported in percentages—and every 2% represents one person. Those registering change by 5 or 6 units are, in most cases, different people.

**Table 4.** PACQLQ item-by-item differences between paper and EDC.

PACQLQ items (each having a 7-point response scale)	Pearson corr.	% With same response	% Patients differing by					
			1 unit	2 units	3 units	4 units	5 units	6 units
AQ1 Feel helpless or frightened	0.60	54	29	8	4	2	2	0
AQ2 Family need to change plans	0.50	59	20	12	8	0	0	0
AQ3 Feel frustrated or impatient	0.61	47	31	14	8	0	0	0
AQ4 Interfere with your job	0.67	51	33	10	4	2	0	0
AQ5 Feel upset	0.60	53	27	16	2	0	0	2
AQ6 Sleepless nights	0.69	69	18	8	0	2	2	0
AQ7 Bothered with interference	0.67	74	18	4	4	0	0	0
AQ8 Awakened during the night	0.67	55	31	8	6	0	0	0
AQ9 Feel angry	0.71	73	17	6	4	0	0	0
AQ10 Concerned with child's performance	0.64	51	37	8	2	2	0	0
AQ11 Concerned about meds and side-effects	0.82	59	31	6	2	2	0	0
AQ12 Concerned about being overprotective	0.82	47	43	10	0	0	0	0
AQ13 Concerned about child leading normal life	0.62	57	22	14	4	0	2	0

Note: The figures are reported in percentages—and every 2% represents one person. Those registering change by 5 or 6 units are, in most cases, different people.

**Table 5.** Differences between paper and electronic versions of the asthma QOL scales.

	Mean score (SD)		P-value (t-test)	Intraclass correlation coefficient
	Paper	Electronic		
AQLQ(S) scale				
Overall	5.32 (1.10)	5.34 (1.01)	.61	0.96
Activity limitation	5.55 (1.16)	5.61 (1.04)	.24	0.95
Symptoms	5.19 (1.14)	5.22 (1.09)	.63	0.93
Emotional function	5.19 (1.39)	5.17 (1.33)	.78	0.93
Environmental function	5.22 (1.24)	5.17 (1.13)	.52	0.90
PAQLQ(S) scale				
Overall	5.42 (1.21)	5.34 (1.14)	.76	0.93
Activity limitation	5.32 (1.17)	5.32 (1.06)	.99	0.89
Symptoms	5.23 (1.28)	5.22 (1.24)	.95	0.92
Emotional function	5.70 (1.36)	5.51 (1.34)	.48	0.91
PACQLQ scale				
Overall	5.79 (1.09)	5.87 (0.96)	.40	0.82
Activity limitation	5.85 (1.30)	5.99 (1.03)	.26	0.72
Emotional function	5.77 (1.10)	5.81 (1.02)	.61	0.84

**Table 6.** Convergent validity of asthma scales with external VAS items.

	Spearman correlation	
	Paper	Electronic
AQLQ(S) scale		
Activity limitation domain with VAS: During the last 2 weeks, how much difficulty or limitation have you experienced, as a result of your asthma?	0.89	0.80
Emotional function subscale with VAS: During the last 2 weeks, how much concern, frustration, or distress have you experienced, as a result of your asthma?	0.89	0.85
PAQLQ(S) scale		
Activity limitation subscale with VAS: During the last week, how much has your asthma caused you problems with your ability to do things?	0.61	0.66
Emotional function subscale with VAS: During the last week, how bothered have you been by your asthma?	0.70	0.70
PACQLQ scale		
Activity limitation subscale with VAS: During the past week, how much has the impact of your child's asthma interfered with your usual activities or lifestyle?	0.36	0.79
Emotional function subscale with VAS: During the past week, how much concern, frustration, or distress have you experienced as a result of your child's asthma?	0.61	0.66

paper and pencil vs. an EDC format. This was done by recruiting asthmatic adults, asthmatic children, and caregivers of children with asthma and examining the concordance between their administrations of the surveys.

The results from this study show that the means of the three scales did not differ significantly between the two methods of administration. *T*-test comparisons as well as intraclass correlation coefficients were tested and all results maintain that the scores from

425 **Table 7.** Test-retest reliability (1-week ICC) of the  
426 electronic version.

	Intraclass correlation coefficient
427	
428	
429	
430	AQLQ(S) scale (electronic version)
431	Overall 0.88
432	Activity limitation 0.90
433	Symptoms 0.87
434	Emotional function 0.81
435	Environmental stimuli 0.85
436	PAQLQ(S) scale (electronic version)
437	Overall 0.78
438	Activity limitation 0.66
439	Symptoms 0.76
440	Emotional function 0.80
441	PACQLQ scale (electronic version)
442	Overall 0.85
443	Activity limitation 0.78
444	Emotional function 0.85

447 **Table 8.** Patient preference between paper and electronic  
448 surveys.

	Paper	Electronic	No difference
450			
451			
452			
453			
454			
455			
456			
457			
458			
459			
460			

461 *Note:* Remaining percentages are missing responses.

462  
463  
464  
465 both methods were similar. Additionally, ICC values  
466 that range between 0.90 and 0.96 are very similar to  
467 the original AQLQ paper test-retest measurement  
468 properties conducted by Juniper et al. (ICCs range  
469 from 0.89 to 0.94) (10), as well as those found by  
470 Caro et al. comparing electronic vs. paper versions  
471 of the AQLQ (ICCs range from 0.97 to 0.99) (14).  
472 The PACQLQ results provided the biggest (yet non-  
473 significant) differences between methods, but again,  
474 these are caregivers of children and not the patients  
475 themselves responding to QOL issues.

476 Independent questions to measure convergence  
477 between each method were developed based on the

existing domains of activity limitation and emotional function. Using Spearman correlations, concordance was met in all but the relation between the PACQLQ activity limitation subscale and the VAS item developed for that domain. The correlation for the paper version was 0.36 and 0.79 for the electronic version. Outside of the paper correlation being a spurious finding, possible difficulties with the phrasing and content of the VAS item itself could play a part in the explanation. As well, it was not debriefed on patients before this study and might have proven to have less relevance to that group.

Although most participants agreed that the electronic method was easier to use, a greater percent actually preferred this method. In fact, 82% of adults, 90% of children, and 90% of caregivers appeared to either prefer the computer or find no difference between the two methods. It is not surprising that the percentage was the highest in the population of children (77%) because this population is more involved in the computer generation.

In general, the elapsed time to complete the measures was shorter for the electronic version, though not significant: AQLQ(S) about 7 minutes, PAQLQ(S) about 5 minutes, and the PACQLQ about 4 minutes.

The limitations of our study included the relatively small sample size for each asthmatic population and that our recruitment, because it was not a clinical trial, lacked 100% assurance (based on International Classification of Diseases–9 or forced expiratory volume in 1 second) of asthma diagnosis. However, physicians were asked to recruit patients under current treatment for asthma, and the overall population reported at least mild symptomatology of asthma. Also, the sample was drawn from two urban areas (Raleigh, NC, and Denver, CO), two areas that may include more literate and computer knowledgeable patients. In addition, the clinics are also well-established asthma clinics and have conducted many asthma research studies.

Using hand-held computer devices to capture data is an extremely useful resource. This method of collecting data provides quick and easy access to the data (1,7,23), improves accuracy of data, (4,21,22,24), and increases productivity by saving time (1,4,7). As these devices become increasingly common, the collecting and exchanging of data, for any type of study, with their use will be practical and valuable.

The questionnaires used in this study are used extensively in clinical trials. Electronic method of HRQOL data capture reduces site burden and yields better data quality by ensuring completeness

478 and reducing errors associated with data entry. This  
 479 study suggests that the AQLQ(S), PAQLQ(S), and  
 480 the PACQLQ is a psychometrically sound alternative  
 481 to traditional paper-and-pencil method of HRQOL  
 482 data collection.

### 485 *Appendix 1. Visual analog scales (VAS)*

#### 487 AQLQ(S):

488 During the last 2 weeks, how much *difficulty or*  
 489 *limitation* have you experienced, as a result of  
 490 your asthma?

491 During the last 2 weeks, how much *concern, frus-*  
 492 *tration, or distress* have you experienced, as a  
 493 result of your asthma?

#### 494 PAQLQ(S):

495 During the last week, how *bothered* have you  
 496 been by your asthma?

497 During the last week, how much has your asthma  
 498 caused you *problems* with your ability to do  
 499 things?

#### 501 PACQLQ:

502 During the past week, how much has the impact  
 503 of your child's asthma *interfered* with your usual  
 504 activities or lifestyle?

505 During the past week, how much *concern,*  
 506 *frustration, or distress* have you experienced as  
 507 a result of your child's asthma?

### 508 *Appendix 2. Global rating of change*

509  
 510  
 511  
 512 In the last 24 hours, has there been any **change in your**  
 513 **overall quality of life because of your asthma?**

514 *(Please circle the number of your answer)*

515 0 About the same

516 1 Better (Go to a)

517 2 Worse (Go to b)

518  
 519 (a) If your *overall quality of life because of your*  
 520 *asthma* has gotten "better" in the last 24 hours,  
 521 please indicate *how much it has changed?* (*circle*  
 522 *the number of your answer*)

523 7 A very great deal

524 6 A great deal

525 5 A good deal

526 4 Moderately

527 3 Somewhat

528 2 A little

529 1 Almost the same, hardly at all

530 0 *Not applicable*

(b) If your *overall quality of life because of your*  
*asthma* has gotten "worse" in the last 24 hours,  
 please indicate *how much it has changed?* (*circle*  
*the number of your answer*)

7 A very great deal

6 A great deal

5 A good deal

4 Moderately

3 Somewhat

2 A little

1 Almost the same, hardly at all

0 Not applicable

### *Appendix 3. Ease of use questions*

Which method was easier to use?

*(Please circle your answer)*

A. Paper and pencil

B. Computer

C. No difference

If there were a choice, which method of completing  
 the questionnaire would you prefer?

*(Please circle your answer)*

A. Paper and pencil

B. Computer

C. No difference

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