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The Technology – Activities of Daily Living Questionnaire: A Version with a Technology-Related Subscale

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Key Words

Alzheimer's disease · Activities of daily living · Functional assessment · Activities of Daily Living Questionnaire · Validity · Technology assessment

Abstract

Background: Information and communication technology (ICT) has become an increasingly important part of daily life. The ability to use technology is becoming essential for autonomous functioning in society. Current functional scales for patients with cognitive impairment do not evaluate the use of technology. The objective of this study was to develop and validate a new version of the Activities of Daily Living Questionnaire (ADLQ) that incorporates an ICT subscale. ***Method:*** A new technology-based subscale was incorporated into the Spanish version of the ADLQ (SV-ADLQ), entitled the Technology version of the ADLQ (T-ADLQ). The T-ADLQ was administered to 63 caregivers of dementia patients, 21 proxies of mild cognitive impairment patients and 44 proxies of normal elderly subjects (mean age of the sample ± SD: 73.5 ± 8.30 years). We analysed the convergent validity, internal consistency, reliability cut-off point, sensitivity and specificity of the T-ADLQ. The results of the T-ADLQ were compared to the SV-ADLQ. ***Results:*** The T-ADLQ showed significant correlations with the Mini-Mental State Examination (MMSE), the Frontal Assessment Battery (FAB) as well as other measures of functional impairment and dementia severity (MMSE: $r = -0.70$; FAB: $r = -0.65$; Functional Assessment Questionnaire: $r = 0.77$; Instrumental Activities of Daily Living Scale: $r = -0.75$; Clinical Dementia Rating Scale: $r = 0.72$; $p < 0.001$). The T-ADLQ showed a good reliability with a relatively high Cronbach's α-coefficient (Cronbach's $\alpha = 0.861$). When considering a functional impairment cut-off point greater than 29.25%, the sensitivity and specificity of the T-ADLQ were 82 and 90%, respectively. The area under the receiver-operating characteristic curve was 0.937 for the T-ADLQ and 0.932 for the original version of the test. ***Conclusions:*** The T-ADLQ revealed adequate indicators of validity and reliability for the functional assessment of activities of daily living in dementia patients. However, the inclusion of technology items in the T-ADLQ did not improve the performance of the scale, which may reflect the lack of widespread use of technology by elderly individuals. Thus, although it appeared reasonable to add technology use questions to the ADLQ, our experience suggested that this has to be done cautiously, since the sensitivity of these additional items could vary

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in different populations. The T-ADLQ needs to be validated in a different population of dementia subjects.

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Introduction

Dementia is a disorder characterised by cognitive decline and impaired performance in activities of daily living (ADL) and is a major public health issue in the 21st century. The prevalence of dementia increases exponentially with age. Dementia affects 1 in 10 people over 65 years of age and approximately half of people over 85 [1, 2]. It has been estimated that 36 million people worldwide currently suffer from dementia, and that the number of cases will triple by 2040 [3, 4].

A diagnosis of dementia is based on the presence of cognitive impairment associated with acquired functional impairment in ADL, therefore the determination of the presence and severity of impairment in ADL is critical for the diagnosis of dementia [5]. Several different scales for functional assessment of impairment have been developed during the last two decades (for a recent review, see Sikkes et al. [6]). Recently, Johnson et al. [7] proposed that the Activities of Daily Living Questionnaire (ADLQ), which is an informant-based assessment of functional abilities, could be used for the assessment of patients with probable Alzheimer's disease (AD) and other forms of dementia. This scale is composed of 6 subscales that are used to assess 6 domains of basic and instrumental ADL. A global impairment score and a specific functional deterioration score for each of the 6 subscales are produced. The ADLQ avoids certain limitations of other functional scales. A profile description of functional impairment is generated which can be used to track the progression of functional decline over time and is applicable to different dementia syndromes [7, 8]. In addition, the ADLQ has been validated for use in both the Chinese and Spanish languages [9, 10].

Due to the dramatic increase in the use of information and communication technology (ICT), daily activities increasingly include ICT regardless of whether people have the ability to use the technology or not [11, 12]. The ability to use ICT will be essential for autonomous functioning in society. Although technology has permeated all aspects of contemporary life, functional assessment scales for dementia and mild cognitive impairment (MCI) have not yet included an assessment of the use of technology [13]. Three instruments have been designed to exclusively assess competence in the use of common technology in elderly patients with or without cognitive impairment and/or dementia: the ETUQ research protocols [14], the S-ETUQ [15] and the study protocols for META [16]. To the best of our knowledge, there are no functional scales that include the technology domain together with questions regarding basic and instrumental ADL that would allow for a compressive evaluation of ADL. The objective of this study was to validate and examine the diagnostic utility of the Technology Activities of Daily Living Questionnaire (T-ADLQ), which is an extension of the original ADLQ that includes an ICT subscale, in patients with dementia and to explore performances on the T-ADLQ in patients with MCI.

Methods

Participants and Procedures

The study participants were recruited from the Cognitive Neurology and Dementias Unit (Unidad de Neurología Cognitiva y Demencias) of the Neurology Service at the Hospital del Salvador in Santiago, Chile. Controls were recruited from a variety of sources.

The study was carried out in a convenience sample, which included subjects who could be tested and who could have sufficient variability in their ADL to examine the properties of the questionnaire.

The diagnoses of dementia and MCI were provided by a neurologist based on detailed neurological, neuropsychological, laboratory and neuro-imaging data from each participant. The first step in the diagnostic process for dementia was to determine the presence of dementia using the DSM-IV-TR criteria [5]. If these criteria were met, the neurologist determined the specific types of dementia using multiple diagnostic criteria for AD (i.e. NINCDS-ADRDA), vascular dementia (i.e. ADDTC, NINDS-AIREN), dementia with Lewy bodies (i.e. third report of the DLB Consortium) or frontotemporal dementia (i.e. consensus for FTD diagnosis) [17–20]. There were 63 dementia patients (45 patients with AD, 11 with frontotemporal dementia, 4 with vascular dementia and 3 with Lewy body dementia). The diagnosis of MCI was established according to the consensus criteria of the International Working Group on MCI [21]. The MCI group included 21 subjects with memory and non-memory deficits, and the control group included 44 subjects without pre-existing neurological disorders that could potentially cause neuropsychological deficits (e.g. stroke, epilepsy, movement disorder, brain tumour or severe head trauma). All subjects with dementia had a CDR (Clinical Dementia Rating Scale) ≥1, those with MCI had a CDR ≤0.5, and all normal controls had a CDR = 0 [22, 23]. All our controls had normal cognition based on local normative data for the Mini Mental State Examination (MMSE) and the Frontal Assessment Battery (FAB), and were judged to be cognitively normal by the neurologist.

Patients and normal controls had a proxy who provided information about the subjects' problems with their ADL. In the case of individuals with dementia, the proxies were their primary caregivers, which was defined as the person who had the most frequent contact with the patient and who was most directly involved in monitoring the patient's daily functioning. In the case of control subjects, the proxy was a person who knew the individual very well (generally a relative) and who reported to have at least weekly contact with the subject.

All proxies were interviewed to fulfil the CDR. Following the interview, the proxies were asked to complete a suite of questionnaires with functional assessment scales that included the T-ADLQ.

All of the participants signed an informed consent prior to inclusion in the study. This study was approved by the Ethical and Scientific Committee of the Servicio de Salud Metropolitana Oriente.

Instrument

SV-ADLQ and Development of a Technology Subscale for the ADLQ

The Spanish version of the ADLQ (SV-ADLQ) has been validated by Gleichgerrecht et al. [9]. The SV-ADLQ is composed of 6 subscales: Self-care (6 items), Household care (6 items), Employment and recreation (4 items), Shopping and money (3 items), Travel (4 items) and Communication (5 items). Each item is rated on a 4-point scale from 0 (no problem) to 3 (no longer capable of performing the activity). For each item, a rating (number 9) is provided for instances in which the patient may never have performed that activity in the past (ND – 'Never did this activity'), stopped the activity prior to the onset of dementia (e.g. stopped working before dementia symptoms were apparent), or for which the proxy did not have information due to a variety of reasons (DK – 'Don't know') [7].

To assess technology use, a new subscale was created with the same structure as the existing subscales of the SV-ADLQ. Five common domains of technology use were selected: use of a computer, use of a cell phone, use of an ATM, Internet access and E-mail use (online suppl. appendix; for all online suppl. material, see www.karger.com/doi/10.1159/000338606). The final scale including the new technology subscale (T-ADLQ) was divided into 7 sections.

Each item was scored based on the procedure developed by Johnson et al. [7]. The overall functional impairment was calculated for each domain as well as for the global questionnaire as follows: (sum of all ratings not ND/DK)/(3 × total number of items not rated ND/DK). By doing so, items rated as ND/DK were excluded, thereby ensuring that the functional impairment score was based on the actual functioning of the patients relative to their own premorbid performance in ADL. Higher percentage scores indicate major deterioration.

Other Instruments

To determine if the T-ADLQ was a valid measure of disease severity, three alternative instruments were applied to evaluate disease severity: the CDR (a measure of clinical progression and staging), the Chilean version of the MMSE (a general measure of cognitive impairment) and the FAB (a brief bedside cognitive and behavioural battery to measure frontal lobe functioning) [22, 24, 25].

To study the concurrent validity of the T-ADLQ, we applied the Pfeffer Functional Assessment Questionnaire (PFAQ) [26] and the IADL Scale [27], which are also informant-completed functional scales.

Statistical Analysis

Descriptive and comparative analyses were conducted using either analysis of variance (ANOVA) to compare the three groups for continuous variables and the χ^2 test for categorical variables. A multivariate ANOVA was conducted to compare results across subscales of the T-ADLQ by diagnosis category and by gender. A multiple regression analysis was performed to evaluate which demographic variables were associated with ND/DK responses in the new technology subscale.

Convergent validity of the T-ADLQ was evaluated by assessing the association between performance on the T-ADLQ and on the other scales that were administered with Pearson's correlation. Internal consistency was measured by calculating Cronbach's α, which reflects the average interitem correlation score and, as such, will increase when correlations between the items increase [28]. A ROC (receiver-operating characteristic) analysis was performed to determine the ability of the T-ADLQ to discriminate between normal controls (CDR = 0) and dementia patients (CDR ≥1). The AUC (area under the curve) was used as a measure of the accuracy of the T-ADLQ and the SV-ADLQ questionnaires to distinguish between normal controls and dementia patients. AUC values that were less than perfect (1.0) were classified as having excellent (>0.9), good (>0.8), fair (>0.7) or poor (>0.6) accuracy [29]. The ROC curve was also used to select an optimal cut-off value of the percentage of functional impairment above which an individual has a very high chance of suffering from dementia. The analyses were conducted at $p < 0.05$ (two-tailed) using the program PASW 18 for Microsoft Windows (SPSS Inc., Chicago, Ill., USA). In addition, the effect sizes (Cohen's d statistic) were calculated to determine the magnitude of the group differences in the T-ADLQ. According to Cohen, effect sizes ranging from 0.2 to 0.49 are small, from 0.5 to 0.79 are medium, and greater than 0.8 are large. Positive effect sizes indicate lower performance in people with dementia compared to their control counterparts. The analysis was performed on the SV-ADLQ and the T-ADLQ to compare both scales.

Results

Administration

All proxies indicated that they could provide adequate information for the T-ADLQ. The average time of completion was between 10 and 15 min, and none of the participants reported difficulties in understanding the instructions or individual items.

Table 1. Demographic and clinical characteristics of patients with dementia, MCI and normal controls

Parameters	Dementia patients (n = 63)	MCI patients (n =21)	Control subjects (n = 44)	Post-hoc analysis		
				dementia vs. MCI	dementia vs. control	MCI vs. control
Age*, years	73.94±8.71	71.33±9.12	74.05±7.28			
Years of education*	10.76±4.94	11.38±5.09	13.11±4.46			
Gender*, %	46 M (29)	48 M (10)	48 M (21)			
	54 W (34)	52 W (11)	52 W (23)			
Cognitive impairment						
MMSE	17.89±5.81	26.05±2.46	27.84±2.29	**	**	**
FAB	9.03±3.93	13.15±2.64	15.67±2.04	**	**	**
Functional impairment						
PFAQ	15.39±9.45	2.44±3.85	0.64±1.51	**	**	**
IADL	3.66±2.00	6.21±2.12	7.30±1.26	**	**	**
Dementia severity						
CDR	1.89±0.84	0.5±0	0.0±0.0	**	**	*

Results are expressed as the mean ± SD; figures in parentheses indicate numbers. * p > 0.05: not significantly different; ** p < 0.05: significantly different. Post-hoc analysis was carried out with the Games-Howell test.

Demographic and Clinical Data

The total sample included 128 subjects (60 men and 68 women). The control group included 44 subjects (21 men and 23 women), the MCI group included 21 subjects (10 men and 11 women) and the dementia group included 63 subjects (29 men and 34 women). Table 1 summarises the demographic characteristics and clinical profiles of the three groups. No significant differences ($p > 0.05$) were found between the three groups with respect to the age ($F_{2, 127} = 0.892$; $p = 0.413$), years of education ($F_{2, 123} = 3.08$; $p = 0.5$) or sex ($\chi^2_{128, 2} = 0.910$; $p = 0.635$). The three groups differed significantly in the global cognitive efficiency (MMSE; $F_{2, 127} = 73.367$; $p < 0.001$), executive function (FAB; $F_{2, 121} = 54.861$; $p < 0.001$), functional assessment (PFAQ; $F_{2, 124} = 65.973$; $p < 0.001$), IADL ($F_{2, 116} = 50.87$; $p < 0.001$) and total CDR scores ($F_{2, 123} = 48.421$; $p < 0.001$). A post-hoc analysis revealed that dementia and MCI patients, as well as dementia patients and controls, were significantly different in all these measures ($p < 0.05$). MCI patients and controls differed significantly only in the CDR scale (table 1).

Answer Characteristics

For the set of 128 participants, the average number of ND/DK responses on items included in the Technology subscale was 65.62 ± 36.79% (mean ± SD). The items most frequently rated as ND/DK were '7E – E-mail access' (79.7% of the answers), '7D – Internet access' (75.8%) and '7A – Computer access' (70.3%). The percentage of ND/DK responses on items included in the original SV-ADLQ was 9.1 ± 7.42% and ranged from 51.6% (item '5B – Driving') to less than 2% (items '5A – Taking pills or medicine', '4E – Travel outside familiar environment', '2F – Talking', '3F – Understanding' and '3D – Travel'). Items that did not have any ND/DK answers were '1A – Eating', '1C – Bathing', '1D – Elimination', '1F – Interest in personal appearance', '4B – Handling cash' and '6A – Using the telephone' (table 2).

Answer Characteristics of the Technology Subscale

To determine the effects of previous exposure to technology, a multiple regression analysis (Enter Method) was performed with the percentage of ND/DK responses in the technology subscale as dependent variables and the subject-based variables as independent variables (gender, years of education and age). The resulting regression model excluded gender as a factor. Age and education explained 32.4% of the total variance of the percentage of ND/DK ($r^2 = 0.324$, $F_{3, 120} = 19.17$, $p < 0.001$). There was a strong negative effect of years of education (β-coefficient = –0.47, $p < 0.001$) and a positive effect of age (β-coefficient = 0.245, $p = 0.002$). In summary, the percentage of ND/DK responses was lower in less educated and older subjects. The mean percentage of ND/

Table 2. Percentage of ND/DK responses to each item of the T-ADLQ

	Percentage of ND/DK responses		
	total sample (n = 128)	women (n = 68)	men (n = 60)
Self-care activities			
Eating	0.00	0.00	0.00
Dressing	0.78	1.49	0.00
Bathing	0.00	0.00	0.00
Elimination	0.00	0.00	0.00
Taking pills or medicine	2.34	1.49	3.33
Interest in personal appearance	0.00	0.00	0.00
Household care			
Preparing meals, cooking	13.28	0.00	28.33
Setting the table	7.03	1.49	13.33
Housekeeping	13.28	4.48	23.33
Home maintenance	10.94	2.99	20.00
Home repairs	29.69	40.30	18.33
Laundry	28.91	5.97	55.00
Employment and recreation			
Employment	14.84	22,.9	6.67
Recreation	11.72	11.94	11.67
Organizations	27.34	32.84	21.67
Travel	1.56	1.49	1.67
Shopping and money			
Food shopping	4.69	1.49	8.33
Handling cash	0.00	0.00	0.00
Managing finances	7.81	8.96	6.67
Travel			
Public transportation	7.81	4.48	11.67
Driving	51.56	76.12	23.33
Mobility around the neighbourhood	1.56	2.99	0.00
Travel outside familiar environment	2.34	2.99	1.67
Communication			
Using the telephone	0.00	0.00	0.00
Talking	0.78	1.49	0.00
Understanding	0.78	0.00	1.67
Reading	8,59	10.45	6.67
Writing	4.69	5.97	3.33
Technology			
Computer access	70.31	82.09	56.67
Use of cell phones	40.63	41.79	40.00
ATM use	61.72	68.66	55.00
Internet access	75.78	83.58	66.67
E-mail access	79.69	86.57	71.67

DK responses of subjects who were older than 75 (75.65 ± 28.87%) was significantly higher than that of subjects who were younger than 75 (53.79 ± 41.92%; $t_{125} = 3.46$, $p < 0.01$).

Divergent Validity and Sensitivity and Specificity

Table 3 summarises the percentage of functional impairment, according to the T-ADLQ, for each subdomain of ADL and for the global scale in both groups. Functional impairment scores differed significantly between the three groups for each subdomain of the T-ADLQ (multivariate ANOVA $F_{2, 80} = 8.52$; $p < 0.001$]. Post-hoc analyses revealed that dementia patients differed significantly from the control and MCI subjects in the 7 subscales of the T-ADLQ and the total score ($p < 0.001$). Controls and MCI patients were significantly different only in the Employment and recreation and Travel subscales. No significant differences were found in the other 5 subscales, including the Technology subscale (table 3). The three groups differed significantly in the total score of the T-ADLQ (ANOVA $F_{2, 127} = 25.12$, $p < 0.001$] and the SV-ADLQ (ANOVA $F_{2, 125} = 61.45$, $p < 0.001$]. The post-hoc analysis revealed that the dementia group was significantly different from both the controls and the MCI subjects in both scales ($p < 0.001$). Controls and MCI subjects did not differ from each other. The standardised mean differences between the control and dementia groups showed Cohen's d values (effect size r) of 2.13 (0.73) for the T-ADLQ and 2.07 (0.72) for the SV-ADLQ. In a comparison of patients with dementia and patients with MCI, Cohen's d values were 1.71 (0.65) and 1.66 (0.64), respectively; Cohen's d values between the controls and MCI were 0.65 (0.31) and 0.62 (0.29), respectively. The results of the ROC curve analysis of the T-ADLQ and SV-ADLQ are displayed in figure 1 and table 4. The AUC for the T-ADLQ was 0.937 (95% confidence interval: 0.896–0.976), which indicates a high overall diagnostic usefulness of the test [29]. The AUC for the SV-ADLQ was 0.932 (95% confidence interval: 0.888–0.976). The optimal balance between sensitivity and specificity for the T-ADLQ was obtained with a cut-off point of 29.25% of functional impairment (sensitivity = 82%, specificity = 86%). The same cut-off was obtained for the SV-ADLQ.

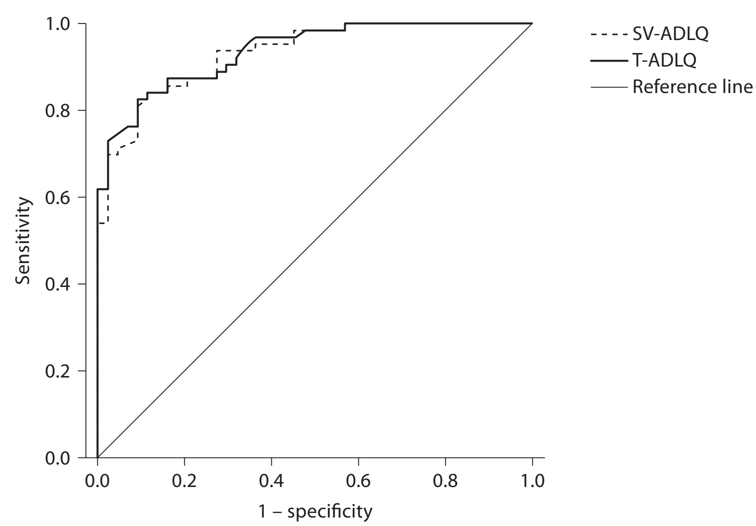
Convergent Validity

The T-ADLQ showed a statistically significant association with other measures of cognitive global efficiency, functional ability and dementia severity. The T-ADLQ total score was significantly correlated with the PFAQ total score (Pearson correlation coefficient $r = 0.77$; $p < 0.001$). This scale revealed greater functional impairment at higher scores. The total T-ADLQ score also showed a significant negative correlation with the IADL ($r = -0.75$; $p < 0.001$), which indicates greater deterioration of func-

Table 3. Percentage of functional impairment in the 7 subscales of the T-ADLQ, the total T-ADLQ and the SV-ADLQ in patients with dementia, MCI and normal controls

Parameters T-ADLQ and SV-ADLQ	Dementia patients (n = 63)	MCI patients (n = 21)	Control subjects (n = 44)	Post-hoc analysis		
				dementia vs. MCI	dementia vs. control	MCI vs. control
Self-care activities	27.42±20.90	7.30±11.70	3.91±6.18	**	**	*
Household care	49.56±30.47	20.42±22.15	17.1970±23.01	**	**	*
Employment and recreation	57.45±21.16	39.42±24.21	25.69±26.08	**	**	**
Shopping and money	60.67±31.34	12.70±19.34	8.96±19.14	**	**	*
Travel	56.66±29.05	28.04±25.04	15.8460±20.48	**	**	**
Communication	48.14±26.46	18.57±3.67	8.2071±12.54842	**	**	*
Technology	66.11±30.30	36.54±23.18	18.17±11.84	**	**	*
Total score T-ADLQ	47.70±21.07	19.59±11.39	12.39±11.84	**	**	*
Total score SV-ADLQ	48.76±20.98	20.12±11.05	12.84±11.41	**	**	*

Results are expressed as the mean ± SD. * $p > 0.05$: not significantly different; ** $p < 0.05$: significantly different. Post-hoc analysis was carried out with the Bonferroni test.



Comparison	Instruments	AuC	Cut-off point	Sensitivity	Specificity	(95%) CI
Dementia vs. Control	SV-ADLQ	0.932	29.25	0.810	0.909	0.888–0.976
	T-ADLQ	0.937	29.25	0.825	0.909	0.895–0.978

Fig. 1. SV-ADLQ and T-ADLQ ROC for the discrimination of patients with dementia and normal controls. ROC curve for each percentage of functional impairment in the SV-ADLQ and the T-ADLQ for discriminating between patients with dementia and normal controls. An ROC sensitivity curve was plotted against 1 minus the specificity. The most discriminative cut-off point was set nearest to the upper left corner of the graph. CI = Confidence interval.

tionality at lower scores. The Technology subscale of the T-ADLQ was significantly correlated with the PFAQ total score ($r = 0.257$; $p = 0.004$), the IADL ($r = -0.21$; $p = 0.030$) and the SV-ADLQ ($r = 0.755$; $p < 0.001$). The T-ADLQ total score was also significantly correlated with measures of dementia severity, such as the CDR score ($r = 0.72$; $p < 0.001$; higher CDR scores indicate greater dementia severity). Finally, the total T-ADLQ score showed a significant negative correlation with the MMSE score ($r = -0.70$; $p < 0.001$) and the FAB ($r = -0.65$; $p < 0.001$; MMSE and FAB low scores indicate greater cognitive deterioration). In summary, the results showed that greater severity of dementia correlated with greater functional impairment, and lower global cognitive efficiency correlated with greater

Table 4. Sensitivity and specificity of various cut-off percentages of functional impairment on the T-ADLQ and SV-ADLQ for the discrimination of dementia patients and normal controls

Cut-off point	SV-ADLQ		T-ADLQ	
	sensitivity	specificity	sensitivity	specificity
25	0.857	0.795	0.873	0.818
26	0.857	0.818	0.873	0.841
26	0.857	0.818	0.857	0.841
27	0.841	0.841	0.841	0.841
28	0.841	0.864	0.841	0.864
28	0.841	0.886	0.841	0.886
29	0.825	0.886	0.825	0.886
29	0.810	0.909	0.825	0.909
30	0.794	0.909	0.810	0.909
31	0.778	0.909	0.794	0.909
32	0.746	0.909	0.778	0.909
32	0.746	0.909	0.762	0.909
33	0.730	0.909	0.762	0.932
35	0.698	0.955	0.730	0.977
37	0.683	0.977	0.714	0.977

Table 5. Comparison between the T-ADLQ and the SV-ADLQ and their respective Pearson correlation coefficients with respect to other instruments

Assessment	Instruments	T-ADLQ (including Technology subscale)	SV-ADLQ (excluding Technology subscale)
Cognitive impairment	MMSE*	–0.702	–0.697
	FAB*	–0.65	–0.643
Functional impairment	PFAQ*	0.775	0.772
	IADL*	–0.697	–0.740
Severity of dementia	CDR*	0.720	0.716

* $p < 0.01$.

functional impairment (table 5). The Pearson correlation coefficient for the relationship between the SV-ADLQ scale and other scales did not differ significantly from the Pearson correlation coefficient for the relationship between the T-ADLQ and the same scales (table 5).

Internal Consistency

The internal consistency of the 28 items in the SV-ADLQ (excluding the new Technology subscale) and of the 33 items in the T-ADLQ (including the new Technology subscale) was high (Cronbach's α-coefficients of 0.861 and 0.848 for the SV-ASLQ and T-ADLQ, respectively), thereby suggesting that the Technology subscale did not significantly decrease the internal consistency of the entire instrument. The internal consistency of each of the 7 subscales was either low (Cronbach's α-value of 0.396 for Travel and 0.539 for Employment and recreation) or high (Cronbach's α-value of 0.688 for Shopping and money, 0.739 for Communication, 0.780 for Household care, 0.739 for Self-care activities and 0.862 for Technology subscale) [30].

Discussion

This study addressed three important issues. First, it validated the T-ADLQ, which is an extension of the SV-ADLQ with a newly developed ICT subscale. Second, it demonstrated that there was an age cohort effect that should be taken into consideration when technology use is examined in elderly individuals. The study showed that the AUC was marginally better with the ICT subscale. However, the inclusion of questions regarding technology use will be critical for the determination of ADL deficits in future generations, and these questions should be incorporated into questionnaires at this stage of research. Third, the scale detected subtle impairments in ADL in MCI and cognitively normal control subjects.

The convergent validity was evidenced by strong relationships between the T-ADLQ and measures of cognitive impairment (MMSE and FAB), other measures of functional impairment (e.g. the IADL and PFAQ) and measures of dementia severity (CDR). The T-ADLQ presented good internal consistency, thereby suggesting that it is a reliable scale for evaluating functional impairment. Our results are consistent with previous investigations that used the ADLQ to assess functional impairment in patients with dementia. Johnson et al. [7] determined in 140 dementia patients that ADLQ scores presented, in terms of convergent validity, a Pearson correlation coefficient of 0.5 with CDR and –0.42 with MMSE ($p < 0.001$). The Chinese version of the ADLQ revealed good convergent validity when compared to the Disability Assessment for Dementia ($r = –0.92$; $p < 0.001$) and with global mental states ($r = –0.80$; $p < 0.001$). Recently, a functional follow-up assessment of the ADLQ in 40 patients with dementia in Argentina reported that the ADLQ showed an appropriate concurrent validity, thereby correlating the ADLQ with the PFAQ ($r = 0.67$; $p < 0.001$) and the CDR ($r = 0.54$; $p < 0.001$) [9].

To our knowledge, no other studies have examined both controls and dementia patients. This allowed us to study the divergent validity and diagnostic usefulness of the ADLQ and the T-ADLQ by calculating the sensitivity and specificity of a cut-off score that discriminates between patients with dementia and controls. Cohen's d values of 2.13 for the T-ADLQ and of 2.07 for the SV-ADLQ for the relationship between the controls and dementia patients indicate that the overlap between the two populations was less than 16.6 and 17.5%, respectively. Both scales discriminate very well between the two populations. Assessments of ability in ADL often rely on clinical judgment with a high risk of proxy bias in the definition of 'essential intact ability' [31, 32]. The availability of a cut-off score, which has a known sensitivity and specificity, to discriminate between patients with dementia and subjects without dementia could allow for a more precise definition of impairment in ADL in subjects with cognitive impairment. Functional assessments could be included in screening for dementia to overcome limitations of cognitive instruments [33, 34].

There is a growing belief that technology use is increasing in all segments of the population. It is therefore reasonable to ask whether changes in technology use (or the ability to use technology) may be a marker for dementia. However, our data showed that for the group of individuals studied, there were no differences in the use of, or the ability to use, technological tools between patients and controls. The fact that the elderly participants in this study were not proficient users of ICT may represent either age cohort or cultural effects or may be related to the venue of the study (i.e. a large, urban population). Thus, although it may appear reasonable to add questions regarding technology use to ADL scales in the future, the sensitivity of these additional questions with respect to cognitive impairment will likely vary based on the specific demographics of the population under study.

The comparisons between the T-ADLQ and the original version of the ADLQ suggest that the incorporation of the new ICT subscale did not improve the psychometric properties and sensitivity of the original scale, probably due to the characteristics of older individuals who have limited use and experience with ICT.

The percentage of ND/DK answers correlated significantly with education and age. Therefore, due to their age and socio-economic status, the high percentage of ND/DK answers in the ICT subscale was an inevitable limitation of the T-ADLQ in our study participants. The sampled population was derived from patients of the Chilean public health system, which is usually associated with low-income families and low educational levels. These groups generally have more limited access to ICT.

The mean age of our sample was greater than 60 years, although Internet and computer technologies have only become popular in recent years. In 2000, only 22.1 and 16.6% of the Chilean population had cell phones and were Internet users, respectively [35], which may have limited the exposure of elderly people to ICT. Despite these problems, we believe that it is important to include technology use in ADL evaluations. First, because the items that are rated as ND/DK are not considered in the analysis of functional impairment, the high percentage of these answers neither affects the reliability of the scale nor overestimates the degree of functional impairment. Second, the incorporation of the new subscale is also supported by its high internal consistency. Third, cell phone prevalence now approaches 100% in Chile, and 41% of Chileans use the Internet [35]. As people between 40 and 50 years old grow older, and as technology becomes pervasive and more affordable, it will occupy a major role in daily life, and ADL scales will need to include items related to technology use. In particular, the inclusion of an ICT subscale would certainly increase the sensitivity of the ADLQ as the items included in the ICT subscale will become critical for determining instrumental ADL performance in future generations [15].

In our study, we found that a cut-off of 29.5% allows for differentiation between control subjects and dementia patients with a high sensitivity (0.80) and specificity (0.86). According to Johnson and collaborators [7], this score indicates the presence of mild functional impairment in ADL in subjects with a CDR score of 0. In a population-based study, Snitz et al. [36] showed that 49% of a sample of subjects with CDR = 0 had impairments in 1 or more cognitive tests, and a sizeable proportion (9%) had impairment in at least 3 tests. Other studies revealed that normally ageing subjects presented functional impairment despite performing in the normal range on neuropsychological tests [37]. In a recent study, 10.1% of normally ageing controls presented mild instrumental ADL restriction [38]. Therefore, normal controls could have impaired performances in either neuropsychological or functional evaluations that are not detected by the CDR [39].

The total scores on the SV-ADLQ and T-ADLQ were statistically different between MCI and dementia patients, but not between normal controls and MCI patients, which could have resulted from the lack of statistical power of our study due to the relatively small number of MCI subjects, or to a ceiling effect of the questionnaire. Nevertheless, there was a tendency for MCI patients to have a greater number of deficits than the normal controls, and they were statistically different in 2 subscales (Employment and recreation as well as Travel), suggesting that there are detectable differences between groups in specific instrumental ADL. Although it is expected that MCI subjects will be more impaired than controls in their instrumental ADL [40–43], our study showed that mild instrumental ADL problems can be seen in normal controls. Longitudinal studies are necessary to determine the outcomes of these impairments in normal controls and MCI patients [44].

Informant-based questionnaires to assess instrumental ADL have been criticised because they are susceptible to potential reporter biases that could result in an under- or overestimation of functional decline [45–47]. Future research should focus on exploring the relationship between caregivers' reports and direct observations of patient performance in tasks evaluated by the scale [10, 48], especially in the new Technology subscale, to ensure the reliability of caregivers' reports on patients' functional abilities using the T-ADLQ. Furthermore, due to the effect of education on the percentage of ND/DK responses in the new technology study, it will be important to explore the difficulties in using technology questionnaires in populations with high and low education levels. Elderly subjects in developing countries have less exposure to technology and lower educational levels than those of Europe or the USA (for example, the average years of total schooling for the population aged 75 or older were 7.2 in Chile, 9.6 in the Netherlands and 12.1 in the USA) [49]. Therefore, these results may not be generalisable to other populations.

In summary, our research suggests that both the SV-ADLQ and T-ADLQ show acceptable psychometric properties and are reliable instruments with good diagnostic accuracy. The T-ADLQ could represent an alternative to a more comprehensive evaluation of functional activities including use of ICT.

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