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Confirmatory factor analysis of the health literacy in dentistry scale (HeLD) in the Australian population

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Objective: To determine the psychometric properties of both the long- and short-form versions of the Health Literacy in Dentistry (HeLD) instrument in a large sample of the Australian adult population. ***Methods:*** Data were from a subset of the National Dental Telephone Interview Survey 2013. Both the long (HeLD-29) and short-form (HeLD-14) were utilised, each of which comprises items from 7 conceptual domains: access, understanding, support, utilization, economic barriers, receptivity and communication. Confirmatory Factor Analysis was performed through structural equation modelling to determine factorial validity, where the χ^2/df, comparative fit, goodness of fit and root mean square error of approximation were used as indices of goodness of fit. Convergent validity was estimated from the average variance extracted (AVE) and composite reliability (CR), while internal consistency was estimated by Cronbach standardized alpha. ***Results:*** The dataset comprised 2,936 Australian adults aged 18+ years. The kurtosis and skewness values indicated an approximation to a normal distribution. Adequate fit was demonstrated for HeLD-14, but not for HeLD-29. Estimates of ≥ 0.50 for AVE and ≥ 0.70 for CR were demonstrated across all factors for both HeLD-29 and HeLD-14, indicating acceptable convergent validity for both forms. Discriminant validity was also demonstrated for both forms. Internal consistency was adequate in the seven conceptual domains for both HeLD forms, with Cronbach's alpha for all subscales being ≥ 0.70. ***Conclusions:*** The psychometric properties of the HeLD instrument in a large sample of the Australian adult population were confirmed. The short form HeLD-14 was more parsimonious than the long-form (HeLD-29).

Key words: *oral health literacy, construct validity, discriminative validity, reliability*

Introduction

The theoretical paradigm that underpins oral health literacy, and its role in oral health outcomes, is that without functional, applied and contextual understanding of both oral health behaviours and oral health services, optimal oral health cannot be reached (Dickson-Swift *et al*. 2014). Oral health literacy, which has the social determinants of health at is heart, is emerging as an important public health construct at an international level with respect to both understanding, and disentangling, oral health inequalities and inequities regarding access to dental services (Nutbeam 2008; Clarkson *et al*. 2010).

Evolving from measures to assess health literacy in medicine, the last decade has seen an abundance of measures designed to capture the essence of oral health literacy. Many of these employ word recognition tests (for example, the Rapid Estimate of Adult Literacy in Dentistry; REALD) (Lee *et al*. 2007), while others include both numerical and literacy constructs (for example, the Test for Functional Health Literacy in Dentistry-TOFHLID) (Gong *et al*. 2007). A criticism of these early tools, although playing an important role in establishing instruments to measure oral health literacy as distinct from general health literacy, is that they are predominately word recognition tests that provide a crude assessment of reading ability relative to oral health terminology. While more recently developed instruments include concepts relating to oral health knowledge (Macek *et al*. 2010; Sabbahi *et al*. 2009), tools that capture important indicators of oral health literacy, such as ability to navigate dental services, are rare. To the best of our knowledge, there is no oral health literacy assessment tool in the current literature that captures oral health literacy with respect to Nutbeam's three conceptual health literacy levels: (1) basic/functional, for example, reading and writing skills for everyday life; (2) communicative/interactional, for example, cognitive and literacy skills combined with social skills and; (3) critical, for example, empowerment to handle information and to have control over situations (Nutbeam 2000).

It is important that future oral health literacy instruments capture domains that reflect an understanding of poor oral health, a knowledge of positive oral health behaviours, an ability to communicate with oral health providers, and confidence in navigating the oral healthcare system. It is also crucial that these measures are accepted by the groups for whom they are intended, and are simple to both administer and interpret. The Health Literacy in Dentistry (HeLD) instrument, based on the tool developed by Jordan and colleagues (2013) to assess health literacy in medicine, was initially developed in partnership with a group of Indigenous Australians. The instrument was found to be valid, reliable and acceptable for use among this group (Jones *et al*. 2014; Jones *et al*. 2015). The strength of HeLD over existing instruments is that it is theoretically underpinned by seven conceptual domains representing access, understanding, support, utilization,

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economic barriers, receptivity and communication, with the instrument estimating an individual's capacity to obtain, process or interpret, and understand basic oral health information and services needed to make appropriate oral health-related decisions. It thus encompasses all three of Nutbeam's three conceptual health literacy principles. The broader oral health community, including clinicians, policy makers and researchers, has since indicated an interest in having the validity of this instrument demonstrated in other, more general, population groups. The purpose of the current study is hence to determine the psychometric sensitivity, validity and reliability of both the long- and short-form versions of the HeLD instrument in a large sample of the Australian adult population. We have elected to use Confirmatory Factor Analysis, as this is the appropriate methodology given that the instrument has already been developed and tested in another population.

Methods

Data, sampling and weighting

Data were obtained from the 2013 National Dental Telephone Interview Survey (NDTIS) and follow-up postal questionnaire conducted by the Australian Research Centre for Population Oral Health. Methods employed in this study are consistent with Strengthening the Reporting of

Observational Studies in Epidemiology (STROBE) guidelines for cross-sectional studies. The NDTIS is a random sample survey conducted every 2-3 years that collects information on the dental health and use of dental services of Australians in all states and territories. In 2013, an overlapping dual sampling frame design was used. The first sampling frame was created from an electronic listing of people/households listed with phone numbers across Australia. A stratified two-stage sample design was used to select a sample by state/territory and region (Capital City/ Rest of State). A systematic sample of records was selected from each stratum using specified sampling fractions. A second frame was used to include households that did not have a listed phone number. This comprised a list of randomly generated mobile telephone numbers, created by a commercial provider. As the mobile numbers did not contain address information, the sampling frame could not be stratified by geographic region. A random sample of people with mobile numbers was selected from the frame and asked to participate, providing there were aged 18+ years.

After completing the initial telephone interview survey, participants were asked if they would complete the follow-up postal questionnaire component. Those who responded positively were then sent a covering letter with the questionnaire and reply-paid envelope enclosed. A reminder postcard was sent two weeks later, with, if necessary, two additional follow-up letters/questionnaires sent subsequent to the postcard.

Because the purpose of the analysis in the current paper was to assess the psychometric properties of the HeLD instrument, as opposed to producing representative estimates, data were not weighted and are therefore not representative.

Ethical approval

Ethical approval for the study was granted by the University of Adelaide's Human Research Ethics Committee (approval number HS-2013-036).

HeLD

The Health Literacy in Dentistry (HeLD) scale is an oral health literacy measurement tool that estimates an individual's capacity to obtain, process or interpret, and understand basic oral health information and services needed to make appropriate oral health-related decisions (Parker *et al*. 2012). The long-form is the HeLD-29, with a subset being the short-form HeLD-14 (Jones *et al*. 2014; Jones *et al*. 2015). Both forms represent 7 conceptual domains: access, understanding, support, utilization, economic barriers, receptivity and communication (See Table 5). Each item was scored using a 5-point Likert scale ranging from 1 ("without any difficulty") to 5 ("Unable to do"). After re-coding of 5 to 0, 4 to 1, 3 to 2, 2 to 3 and 1 to 4, the possible range of summary scores is from 0-116 (HeLD-29) and 0-56 (HeLD-14). Higher scores indicate higher oral health literacy.

Oral health literacy-related covariates

Covariates included social-demographic, dental behavioural, self-rated health and dentate status characteristics. The sociodemographic characteristics included sex, country of birth ('Australia' or 'non-Australia') and highest education level ('tertiary/diploma' or 'Trade certificate or less'). Dental behaviours included tooth brushing frequency ('2+ times per day' or '<2 times per day'), frequency of dental visiting ('last dental visit <2 years ago' or 'last dental visit 2+ years ago') and usual reason for dental visit ('check-up' or 'problem'). Both self-rated general health and self-rated oral health were dichotomised into 'excellent/very good' or 'good, fair or poor'. Self-reported number of teeth was dichotomised, following benchmarks recommended for functional dentition (Hobdell *et al*. 2003), into '21+ teeth' or '<21 teeth'.

Data analysis

The assessments of normality of the HeLD items were estimated by measures of central tendency, variability and shape of the distribution. The literature suggests that there are no severe deviations from normality if the absolute values of Kurtosis are <7 and for skewness are <3 (Zucoloto *et al*. 2014).

Data were then randomly separated into two sub-datasets. Confirmatory Factor Analysis (CFA) assessments were performed to test the fit of the two datasets to the factor structure of both the long (HeLD-29) and short (HeLD-14) forms. The sample size for each dataset was 1468. The CFA assessments were performed through structural equation modelling, with maximum likelihood used to test the fit of the data to the factor structure of both the HeLD-29 and HeLD-14 instruments. Goodness-of-fit of the models were assessed by using chi-square (x^2) and degrees of freedom (*df*), Comparative Fit Index (CFI), Goodness of Fit Index (GFI), Normed Fit Index (NFI) and Root Mean Square Error of Approximation (RMSEA). An acceptable model fit was considered when $x^2/df \leq 2.0$, CFI >0.95, GFI/NFI >0.90 and RMSEA <0.06 (Byrne 2006; Hu 2009; Zucoloto *et al*. 2014). Also, the models (HeLD-29 vs HeLD-14) were compared using Akaike Information Criterion (AIC) to assess goodness-of-fit and to determine which models were preferred. The lower values of these indices indicates a better model fit. The model with a better fit to the data was further pursued in a 2nd-order model to determine a parsimonious explanation.

Convergent validity was used to test the degree of inter-relation for the items of each factor. Convergent validity was estimated by calculating the average variance extracted (AVE) and composite reliability (CR):

$$AVE = \frac{\sum_{n=i}^{n} \lambda^2}{n}$$

$$CR = \frac{(\sum_{i=1}^{n} \lambda_i)^2}{(\sum_{i=1}^{n} \lambda_i)^2 + (\sum_{c=1}^{n} \partial_i)}$$

(n=Number of items for each factor; i=c=1 2 ..n; **λ:** factor weights, ∂_i: items error)

Estimates of AVE ≥ 0.50 and CR ≥ 0.70 were considered to indicate strong inter-relation of items. Discriminant validity was used to determine that items of one factor were not more strongly correlated with another factor. Fomell and Larcker (1981) reported that when AVE_i and AVE_j are greater than the square of the correlation (ρ_{ij}^2) between the factors *i* and *j*, then discriminant validity is adequate. Internal consistency was considered to be acceptable when Cronbach standardized alpha (α) was ≥0.70.

Data analysis was performed using SAS statistical software (SAS 9.4, SAS Institute Inc., Cary, NC, USA).

Results

A total of 6,340 Australians adults aged 18+ years took part in the 2013 National Dental Telephone Interview Survey, with 2,936 (46.3 percent) completing the follow-up postal questionnaire. All analyses pertain to these 2,936. Just under two-thirds of the sample were female and 79 percent had been born in Australia. Just under one-half had obtained a Diploma or above as their highest educational attainment. Three-quarters reported brushing two or more times per day, with 84 percent reporting having last visited a dentist less than two years ago. Around 68 percent reported usually attending for dental care for a check-up. Just under 64 percent reported excellent or very good self-rated general health, with half reporting excellent or very good self-rated oral health. Approximately half the sample reported having 21 or more teeth.

The summary measures for each HeLD-29 item are shown in Table 1. The kurtosis and skewness values indicate an approximation to a normal distribution, meaning the items satisfactorily met the required thresholds for assumptions of normality of an instrument. The mean HeLD-29 score was 101.1, with a standard deviation of 16.8 and a range of 0 to 116. The mean HeLD-14 score was 48.5, with a standard deviation of 8.3 and a range of 0 to 56.

The goodness-of-fit of the HeLD-29 confirmatory factor analysis model was poor, as demonstrated in Table 2. However, satisfactory goodness of fit was demonstrated for the two sub-samples using HeLD-14, with acceptable thresholds for CFI, GFI, NFI and AIC obtained.

The convergent and discriminant validity, internal consistency and squared correlation between factors for HeLD-29 and HeLD-14 are demonstrated in Table 3.

Table 1. Summary measures of each item of the Health Literacy in Dentistry scale; n=2,936

Item	*Mean*	*SD*	*Median*	*Kurtoses*	*Skewness*
1	3.53	0.81	4.00	3.84	-1.94
2	3.50	0.80	4.00	3.32	-1.79
3	3.36	0.86	4.00	1.74	-1.40
4	3.14	0.99	3.00	0.89	-1.13
5	3.75	0.63	4.00	9.91	-3.18
6	3.80	0.58	4.00	8.14	-3.90
7	3.85	0.51	4.00	6.56	-4.66
8	3.83	0.55	4.00	9.82	-4.38
9	3.22	1.14	4.00	1.00	-1.40
10	3.15	1.26	4.00	0.64	-1.35
11	3.17	1.23	4.00	0.69	-1.36
12	3.43	1.02	4.00	2.98	-1.91
13	2.97	1.19	3.00	-0.08	-0.95
14	3.60	0.82	4.00	5.70	-2.38
15	3.27	1.00	4.00	1.12	-1.33
16	3.77	0.61	4.00	5.42	-3.40
17	3.86	0.48	4.00	6.48	-4.61
18	3.86	0.48	4.00	6.24	-4.63
19	3.85	0.51	4.00	8.92	-4.38
20	3.78	0.59	4.00	4.03	-3.44
21	3.71	0.66	4.00	9.21	-2.81
22	3.64	0.75	4.00	6.66	2.48
23	3.26	1.15	4.00	1.36	-1.53
24	3.07	1.23	4.00	0.25	-1.16
25	3.29	1.11	4.00	1.69	-1.60
26	3.62	0.74	4.00	5.97	-2.31
27	3.79	0.55	4.00	4.80	-3.40
28	3.74	0.59	4.00	6.18	-2.86
29	3.74	0.61	4.00	7.71	-3.05
HeLD-29	101.11	16.77	106.00	7.06	-2.18
HeLD-14	48.52	8.28	51.00	6.16	-2.02

Table 2. Goodness of Fit Indices of Confirmatory Factor Analysis for HeLD-29, HeLD-14 and second-order hierarchical model for HeLD-14.

Samples	*λ*	*x^2*	*df*	*CFI*	*GFI*	*NFI*	*RMSEA*	*AIC*
Data I (n=1468)								
HeLD-29	0.40-0.97	4711.6	356	0.88	0.85	0.87	0.089	4869.63
HeLD-14	0.60-0.97	242.76	56	0.99	0.98	0.98	0.047	340.76
HeLD-14 (Second-order hierarchical model)	0.60-0.97	462.50	70	0.97	0.96	0.97	0.062	532.50
Data II (n=1468)								
HeLD-29	0.43-0.95	5051.87	356	0.86	0.79	0.85	0.095	5209.87
HeLD-14	0.65-0.95	222.11	56	0.99	0.98	0.98	0.045	320.11
HeLD-14 (Second-order hierarchical model)	0.65-0.95	467.73	70	0.97	0.96	0.96	0.062	537.7

Notes: λ: factor weights range (min-max); CFI: comparative fit index; GFI: goodness of fit; NFI: Bentler-Bonett Normed fit index; RMSEA: root mean square error of approximation; AIC: Akaike Information Criterion.

Table 3. Convergent and discriminant validity, internal consistency and squared correlation between factors for HeLD-29 and HeLD-14

		HeLD-29							*HeLD-14*						
		1	*2*	*3*	*4*	*5*	*6*	*7*	*1*	*2*	*3*	*4*	*5*	*6*	*7*
Data I (n=1468)		*Discriminant validity (ρ_{ij}^2)*													
Access	1	1.00							1.00						
Understanding	2	0.35	1.00						0.35	1.00					
Support	3	0.09	0.08	1.00					0.07	0.07	1.00				
Utilisation	4	0.46	0.38	0.17	1.00				0.46	0.35	0.17	1.00			
Economic barrier	5	0.21	0.11	0.12	0.20	1.00			0.17	0.08	0.10	0.19	1.00		
Receptivity	6	0.19	0.21	0.14	0.34	0.23	1.00		0.16	0.18	0.12	0.32	0.20	1.00	
Communication	7	0.54	0.30	0.22	0.64	0.34	0.27	1.00	0.42	0.26	0.20	0.66	0.28	0.28	1.00
		Convergent validity													
Average variance extracted (AVE)		0.80	0.81	0.72	0.66	0.67	0.57	0.56	0.92	0.90	0.83	0.82	0.77	0.77	0.59
Composite reliability (CR)		0.99	0.99	0.99	0.99	0.99	0.99	0.99	1.00	1.00	0.99	1.00	0.99	0.99	0.98
Cronbach standardized alpha (α)		0.94-0.95							0.89-0.90						
Squared correlation (r^2)		0.15-0.94							0.20-0.91						
Data II (n=1468)		*Discriminant validity (ρ_{ij}^2)*													
Access	1	1.00							1.00						
Understanding	2	0.39	1.00						0.40	1.00					
Support	3	0.09	0.07	1.00					0.07	0.05	1.00				
Utilisation	4	0.46	0.40	0.13	1.00				0.39	0.32	0.12	1.00			
Economic barrier	5	0.22	0.10	0.18	0.22	1.00			0.17	0.07	0.06	0.23	1.00		
Receptivity	6	0.22	0.22	0.13	0.42	0.22	1.00		0.19	0.17	0.11	0.42	0.19	1.00	
Communication	7	0.54	0.29	0.17	0.61	0.37	0.37	1.00	0.31	0.21	0.12	0.58	0.31	0.27	1.00
		Convergent validity													
Average variance extracted (AVE)		0.80	0.76	0.70	0.62	0.66	0.57	0.53	0.90	0.81	0.82	0.72	0.75	0.75	0.58
Composite reliability (CR)		1.00	1.00	0.99	1.00	0.99	1.00	1.00	0.99	0.99	0.99	0.99	0.99	0.99	0.98
Cronbach standardized alpha (α)		0.94-0.95							0.88-0.90						
Squared correlation (r^2)		0.17-0.91							0.42-0.90						

Note: ρ_{ij}^2: square of the correlation between the factors i and j.

Estimates of ≥ 0.50 for AVE, and ≥ 0.70 for CR were demonstrated across all factors for both HeLD-29 and HeLD-14, indicating acceptable convergent validity for both forms. Discriminant validity was also demonstrated for both long and short-forms of the HeLD, given that the AVE_i and AVE_j were greater than the square of the correlation (ρ_{ij}^2) between the factors *i* and *j* for both instruments. Internal consistency was adequate for the seven factors for both long- (HeLD-29) and short-form (HeLD-14) versions, with Cronbach standardized alpha being ≥0.70 for both.

A hierarchical model was developed only for the short-form version (HeLD-14), due to a better and more parsimonious fit to the data (Table 2 & Figure 1). Based on the fitted model, scores for the second order factors were best estimated by the following formulae:

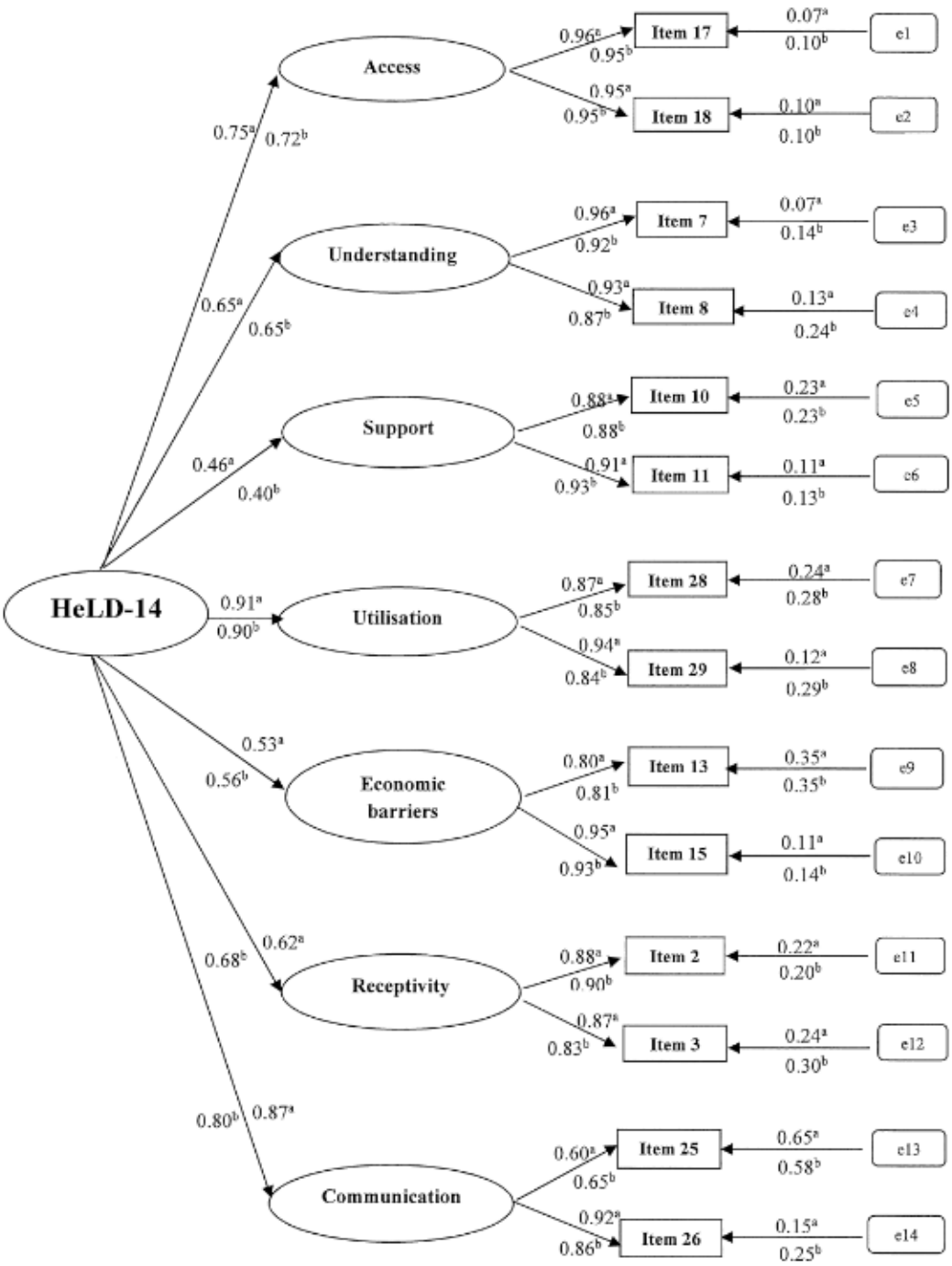

Figure 1. Second-order hierarchical models ('a' and 'b') for the short form oral health literacy instrument (HeLD-14). ('a' value from Data I and 'b' value from Data II. P-value <0.0001 for both models.)

HeLD-14 (Data I), HeLD-14, y = 0.09item$_2$ + 0.05item$_3$ + 0.13item$_7$ + 0.02item$_8$ + 0.02item$_{10}$ + 0.11item$_{11}$+ 0.01item$_{13}$ + 0.22item$_{15}$ + 0.09item$_{17}$ + 0.04item$_{18}$ + 0.01item$_{25}$+ 0.33item$_{26}$+0.09item$_{28}$+0.25item$_{29}$

HeLD-14 (Data II), HeLD-14, y = 0.12item$_2$ + 0.04item$_3$ + 0.07item$_7$ + 0.08item$_8$ + 0.03item$_{10}$ + 0.08item$_{11}$+ 0.01item$_{13}$ + 0.22item$_{15}$ + 0.08item$_{17}$ + 0.06item$_{18}$ + 0.02item$_{25}$+ 0.28item$_{26}$+0.18item$_{28}$+0.11item$_{29}$

These scores resulted from the unstandardized weights matrix presented in Figure 1, which were obtained from the estimates of the covariance between the items and the factors of the instrument (Zucoloto *et al*. 2014). Thus, the response provided by each participant to each item should be multiplied by the estimated weight in the algorithms presented. In this way, the estimate of the construct is calculated more accurately, reflecting the characteristics of the study sample.

Table 4 presents the association between oral health literacy and social demographic characteristics, general and oral health and oral health-related behaviours. Higher scores were observed for either the total HeLD-14 and/or individual components of HeLD-14 among females, those born in Australia, those with high educational attainment, those reporting tooth brushing 2+ times daily, regular dental attenders, those who usually attend for dental care for a check-up, those with excellent or very good self-ratings of general health, those with excellent or very good self-ratings of oral health, and those with 21 or more teeth.

Table 4. Mean (SE) scores for HeLD-14 and its subscales by sample characteristics (n=2,936)

	N (%)	*HeLD-14*	*Access*	*Under-standing*	*Support*	*Utilisation*	*Economic barriers*	*Receptivity*	*Communi-cation*
					Mean (SE)				
Sex									
Male	1090 (37.1)	*46.3 (0.2)	*7.5 (0.0)	*7.6 (0.0)	*5.6 (0.1)	*7.2 (0.0)	5.8 (0.1)	*6.4 (0.1)	*6.5 (0.1)
Female	1846 (62.9)	48.0 (0.2)	7.7 (0.0)	7.7 (0.0)	6.4 (0.1)	7.4 (0.0)	5.7 (0.1)	6.7 (0.0)	6.9 (0.0)
Country of birth									
Australia	2310 (78.7)	47.0 (0.2)	7.6 (0.0)	*7.6 (0.0)	6.2 (0.1)	**7.3 (0.0)	5.8 (0.1)	6.5 (0.0)	6.7 (0.0)
Non-Australia	626 (21.3)	47.7 (0.3)	7.6 (0.0)	7.7 (0.0)	6.2 (0.1)	7.4 (0.0)	5.7 (0.1)	6.6 (0.1)	6.8 (0.1)
Education level									
Diploma or above	1403 (47.8)	*48.4 (0.3)	*7.7 (0.0)	*7.8 (0.0)	6.3 (0.1)	*7.4 (0.0)	*6.2 (0.1)	6.6 (0.1)	*7.0 (0.1)
Certificate or less	1533 (52.2)	46.5 (0.2)	7.5 (0.0)	7.6 (0.0)	6.1 (0.1)	7.3 (0.0)	5.5 (0.1)	6.5 (0.0)	6.6 (0.0)
Tooth brushing									
>=2/day	2113 (75.5)	*48.4 (0.2)	*7.7 (0.0)	*7.7 (0.0)	*6.3 (0.1)	*7.5 (0.0)	*6.0 (0.0)	*6.7 (0.0)	*6.9 (0.0)
<2/day	686 (24.5)	43.9 (0.3)	7.4 (0.0)	7.4 (0.0)	5.8 (0.1)	6.9 (0.1)	5.2 (0.1)	5.9 (0.1)	6.2 (0.1)
Missing	137								
Dental visiting									
Last visit<2 years	2451 (83.6)	*48.3 (0.3)	*7.7 (0.0)	*7.7 (0.0)	*6.3 (0.1)	*7.4 (0.0)	*6.1 (0.1)	*6.7 (0.0)	*6.9 (0.0)
(Last visit >= 2 years	481 (16.4)	44.3 (0.6)	7.1 (0.0)	7.4 (0.0)	5.7 (0.1)	7.0 (0.1)	4.5 (0.1)	5.9 (0.1)	6.2 (0.1)
Missing	4								
Reason dental vising									
Check-up	1986 (68.1)	*48.8 (0.2)	*7.7 (0.0)	*7.7 (0.0)	*6.5 (0.1)	*7.5 (0.0)	*6.3 (0.1)	*6.8 (0.0)	*7.0 (0.0)
Problem	929 (31.9)	43.6 (0.3)	7.4 (0.0)	7.6 (0.0)	5.7 (0.1)	7.1 (0.0)	4.7 (0.1)	6.1 (0.1)	6.3 (0.1)
Missing	21								
Self-rated general health									
Excellent/Very good	1870 (63.8)	*48.9 (0.2)	*7.7 (0.03)	*7.8 (0.0)	*6.5 (0.1)	*7.5 (0.0)	*6.2 (0.1)	*6.8 (0.0)	*7.0 (0.0)
Good/Fair/Poor	1062 (36.2)	44.4 (0.3)	7.4 (0.03)	7.4 (0.0)	5.8 (0.1)	7.0 (0.0)	5.0 (0.1)	6.1 (0.1)	6.3 (0.1)
Missing	4								
Self-rated oral health									
Excellent/Very good	1422 (50.8)	*49.8 (0.2)	*7.8 (0.03)	*7.8 (0.0)	*6.6 (0.1)	*7.5 (0.0)	*6.5 (0.1)	*6.9 (0.1)	*7.1 (0.1)
Good/Fair/Poor	1375 (49.2)	44.7 (0.2)	7.4 (0.0)	7.5 (0.0)	5.8 (0.1)	7.1 (0.0)	5.0 (0.1)	6.1 (0.0)	6.4 (0.0)
Missing	139								
Number teeth									
≥21	2378 (85.1)	*47.4 (0.2)	7.6 (0.0)	*7.7 (0.0)	*6.2 (0.1)	*7.3 (0.0)	*5.9 (0.1)	6.5 (0.0)	*6.8 (0.0)
<21	415 (14.9)	45.1 (0.5)	7.5 (0.1)	7.4 (0.1)	5.9 (0.1)	7.1 (0.1)	5.0 (0.1)	6.6 (0.1)	6.3 (0.1)

Notes: *: $p<0.05$

Discussion

Our findings demonstrated that the psychometric properties of the HeLD instrument were good for the short-form, but less so for the long-form, in a large sample of the Australian adult population. To the best of our knowledge, the HeLD instrument has yet to be utilised in populations outside of Australia, meaning we are unable to compare our findings with others in the literature. Others hoping to implement the HeLD instrument will need to confirm the validity and reliability of these psychometric scales prior to their application in each study sample.

The grouping of factors according to the proximity of the theoretical concepts into the seven conceptual domains of HeLD has been published (Jones *et al*. 2014; Jones *et al*. 2015). However, to the best of our knowledge, this grouping has not had its construct validity tested through a confirmatory methodology, which is important for an accurate estimation of the contribution of the items and factors for the calculation of the concepts evaluated.

The method proposed for the HeLD is to sum the responses of each item (Jones *et al*. 2014; Jones *et al*. 2015). Based on this, and because of the need to improve the accuracy of the estimates of the measured construct (oral health literacy), the use of the second-order algorithm for the calculation of the scores for each subscale, and an overall score for the instrument, allows for a better understanding and comparison of the results obtained. This proposal can be used in the context of different populations, given that it allows estimating the HeLD-14 item weights individually.

The aim of this paper was to assess the psychometric properties of the HeLD instrument in a large sample of the Australian population. We did not aim to generate representative findings, thus the data were not weighted. In future analysis, data will be weighted to enable population characteristics and associations with HeLD to be described.

The development, implementation and evaluation of public health interventions for oral health literacy require that the prevalence of oral health literacy be monitored at several levels of the population. The HeLD instrument offers a measure that is non-resource-intensive and which could be readily implemented in any state-based surveillance system. The existence and use of such a valid, low-cost, and low-resource self-reported measure of oral health literacy is beneficial in a range of ways:

Table 5. The Health Literacy in Dentistry (HeLD) instrument 29 items (items in bold pertain to HeLD-14 items)

Are you able to find the energy to manage your dental or oral health?
Are you able to pay attention to your dental or oral health?
Are you able to make time for things that are good for your dental or oral health?
Are you able to change your lifestyle to improve your dental or oral health?
Are you able to find dental health information in a language you understand?
Are you able to fill in dental forms eg enrolment forms?
Are you able to read written information eg leaflets given to you by your dentist?
Are you able to read dental or oral health information brochures left in dental clinics and waiting rooms?
Are you able to discuss your dental or oral health with people other than a dentist?
Are you able to take family or a friend with you to a dental appointment?
Are you able to ask someone to go with you to a dental appointment?
Are you able to ask family or friends for help to understand dental or oral health information?
Are you able to pay to see a dentist?
Are you able to afford transport to dental clinics?
Are you able to pay for medication to manage your dental or oral health?
Do you know where a dentist can be contacted?
Do you know how to get a dentist appointment?
Do you know what to do to get a dentist appointment?
Do you know where you can see a dentist?
Are you able to ask a dentist questions to help you understand dental information?
Are you able to get the information you need when seeing a dentist?
Are you able to follow up with a dentist to understand information about your dental health?
Are you able to change to a different dentist to get better dental care?
Are you able to get a second opinion about your dental health from a dental health professional?
Are you able to look for a second opinion about your dental health from a dental health professional?
Are you able to use information from a dentist to make decisions about your dental health?
Are you able to follow instructions that a dentist gives you?
Are you able to carry out instructions that a dentist gives you?
Are you able to use advice from a dentist to make decisions about your dental health?

Answer:
[1] Without any difficulty
[2] Little difficulty
[3] With some difficulty
[4] Very difficult
[5] Unable to do

(1) it facilitates epidemiological studies of oral health literacy on a large scale; (2) questions regarding oral health literacy could easily be added to ongoing studies to evaluate associations with both general and oral health conditions; (3) the accessibility and acceptability of HeLD (in Australia at least) make it an easy and low-cost method of obtaining data for research that would complement the creation of oral health literacy-related promotion initiatives and; (4) use of HeLD for monitoring would allow for surveillance of the oral health literacy of populations (and sub-populations of interest) over time, in international, national, state, or regional surveillance programs.

It is important to point out that validity is not a property of the instrument per se, but of the instrument when applied to a sample (Anastasi, 1988). That is, the scores in our analyses attributed to the HeLD construct are directly influenced by the very characteristics of the study participants. This is why it is important to test the models' fit when the sample characteristics are different, to thus determine the best structure and to compute the weights to be used for weighting the responses to the items. It is also important to highlight that the HeLD instrument still has limitations with respect to capturing the principle essence of oral health literacy.

While the development of such a comprehensive assessment tool remains a challenging goal, the success of the HeLD instrument is underscored in its ability to capture the three concepts of health literacy that Nutbeam (2000) considered critical; (1) basic/functional oral health literacy for everyday life; (2) communicative/interactional, for example, cognitive and literacy skills combined with social skills to influence overall oral health literacy and (3) critical health literacy, that is, provides an indication of a populations' ability to manage oral health-related information and/or to have control over oral health-related situations. What the HeLD instrument adds, that others lack, is a theoretically underpinned, intuitive, easy-to-use and low cost tool that can be used at a surveillance level to assess and monitor an important oral health construct. At an international level, the context-dependant nature of dental patient–dental provider communication leaves ample room for future investigation. Further validation in other groups and settings is thus crucial to confirm the international relevance of this intuitively sensitive oral health literacy instrument that aims to capture a person's ability to seek, understand and use oral health information that is important in them then being able to access and benefit from oral health care services.

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Conflict of interest

The authors have no competing interests to declare.

References

[AIHW] Australian Institute of Health and Welfare. (2016): *Oral Health and dental care in Australia; key facts and figures 2015*. Canberra, (Australia): Cat. no. DEN 229. Canberra: AHIW.

Anastasi, A. (1988): *Psychological testing*. 6th ed. New York (NY): Macmillan.

Byrne, B.M. (2006): *Structural equation modelling with EQS: Basic concepts, applications, and programming*. 2nd ed. Mahwah, NJ: Erlbaum.

Clarkson, J., Watt, R.G., Rugg-Gunn, A.J., Pitiphat, W., Ettinger, R.L., Horowitz, A.M., Petersen, P.E., ten Cate, J.M., Vianna, R., Ferrillo, P., *et al*. (2010): Proceedings: 9th World Congress on Preventive Dentistry: Community Participation and Global Alliances for Lifelong Oral Health for All. *Advances in Dental Research* **22,** 2-30.

Dickson-Swift, V., Kenny, A., Farmer, J., Gussy, M. and Larkins, S. (2014): Measuring oral health literacy: a scoping review of existing tools. *BMC Oral Health* **14**,148.

Fomell, C. and Larcker, D.F. (1981): Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research* **18**, 39-50.

Gong, D.A., Lee, J.Y., Rozier, R.G., Pahel, B.T., Richman, J.A. and Vann, W.F. JR. (2007): Development and testing of the Test of Functional Health Literacy in Dentistry (TOFHLiD). *Journal of Public Health Dentistry* **67**,105-112.

Hobdell, M., Petersen, P.E., Clarkson, J. and Johnson, N. (2003): Global goals for oral health 2020. *International Dental Journal* **53**, 285-288.

Hu, L. and Bentler, P.M. (1999): Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling* **6**, 1-55.

Jordan, J.E., Buchbinder, R., Briggs, A.M., Elsworth, G.R., Busija, L., Batterham, R. and Osborne, R.H. (2013): The health literacy management scale (HeLMS): a measure of an individual's capacity to seek, understand and use health information within the healthcare setting. *Patient Education and Counselling* **91**, 228-235.

Jones, K., Parker, E., Mills, H., Brennan, D. and Jamieson, L.M. (2014): Development and psychometric validation of a Health Literacy in Dentistry scale (HeLD). *Community Dental Health* **31**, 37-43.

Jones, K., Brennan, D., Parker, E. and Jamieson, L. (2015): Development of a short-form Health Literacy Dental Scale (HeLD-14). *Community Dentistry and Oral Epidemiology* **43**,143–151.

Lee, J.Y., Rozier, R.G., Lee, S.Y., Bender, D. and Ruiz, R.E. (2007): Development of a word recognition instrument to test health literacy in dentistry: the REALD-30--a brief communication. *Journal of Public Health Dentistry* **67**, 94-98.

Macek, M.D., Haynes, D., Wells, W., Bauer-Leffler, S., Cotton, P.A. and Parker, R.M. (2010): Measuring conceptual health knowledge in the context of oral health literacy: preliminary results. *Journal of Public Health Dentistry* **70**,197-204.

Nutbeam, D. (2000): Health literacy as a public health goal: a challenge for contemporary health education and communication strategies into the 21st century. *Health Promotion International* **15**, 259–267.

Nutbeam, D. (2008): The evolving concept of health literacy. *Social Science Medicine* **67**, 2072-2078.

Parker, E.J., Misan, G., Chong, A., Mills, H., Roberts-Thomson, K., Horowitz, A.M. and Jamieson, L.M. (2012): An oral health literacy intervention for Indigenous adults in a rural setting in Australia. *BMC Public Health* **12**, 461.

Sabbahi, D.A., Lawrence, H.P., Limeback, H. and Rootman, I. (2009): Development and evaluation of an oral health literacy instrument for adults. *Community Dentistry and Oral Epidemiology* **37**, 451-462.

Zucoloto, M.L., Maroco, J. and Campos, J.A.D.B. (2014): Psychometric properties of the oral health impact profile and new methodological approach. *Journal of Dental Research* **93**, 645-650.